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MICHIGAN STATE UNIVERSITY

AGRICULTURAL EXPERIMENT STATION

EAST LANSING

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EAST LANSING

L. M. TURK, DIRECTOR
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ROOT DISTRIBUTION OF CORN DRILLED IN ROWS

By H. D. FOTH

DEPARTMENT OF SOIL SCIENCE

A KNOWLEDGE OF ROOT DISTRIBUTION is essential for the development of efficient root sampling techniques designed to measure the effects of cultural practices on root growth. The knowledge may also be useful in the interpretation of plant response to cultural practices.

It has been established that corn root distribution is affected by plant spacing (3). Haynes et al. (4) reported that root growth tended to be in the direction of no root occupancy. An 8-inch spacing of plants in 42-inch rows is currently used in many experiments at this station and is also comparable to that recommended for maximum yields where good soil and high fertility exist. This paper presents the results of a root distribution study of corn grown under these conditions. The study was a continuation of work previously reported (2).

PROCEDURE

A metal frame was used to remove two slabs of soil 4 inches thick from the wall of a pit and perpendicular to the row on eight different dates in 1960. One slab was removed directly opposite a corn plant and the other midway between two plants spaced 8 inches apart. Together, the two slabs represented half the root system of one plant.

Each slab was sectioned vertically and laterally. Roots were washed from each quadrant, photographed, oven dried and weighed. Details concerning the experiment and procedure were similar to those of 1959 (2).

In 1960, planting was on June 4. Cultural practices included one shallow cultivation on June 29 and the application of 300 pounds of

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ammonium nitrate per acre on July 15, without cultivation. The variety was Michigan 250 (85-day) and the yield was 110 bushels per acre.

Leaves were never observed rolled, as a result of water shortage in either year, and the soil below 27 inches was moist and plastic on September 12, 1960.

RESULTS AND DISCUSSION

Percentage Distribution During the Growing Season. The root weights at various locations in both slabs of soil were added together and are given in Table 1. The percentage distribution of roots laterally and vertically were calculated for each date.

Percentage of roots at various locations in the soil differed widely

TABLE 1—Grams of roots at various locations in soil representing half the root system of one plant on 8 dates in 1960

Depth, inches	Inches from base of plant laterally							
	0-3		3-9		9-15		15-21	
0-3	.119(*a*)	2.107	.014	.182	—	.080	—	.046
	.345	2.883	.072	.248	.002	.104	.001	.035
	.560	4.431	.171	.800	.058	.038	.040	.045
	.988	4.723	.175	.796	.110	.085	.053	.030
3-6	.028	.764	.317	.486	.011	.458	—	.203
	.418	1.181	.219	.322	.016	.202	.027	.100
	.260	1.284	.445	.960	.098	.166	.136	.150
	.521	1.426	.432	.910	.154	.279	.250	.108
6-9	.006	.403	.008	.648	.009	.330	—	.365
	.122	.315	.337	.392	.091	.278	.014	.083
	.204	.224	.285	.919	.226	.281	.319	.351
	.358	.670	.629	.589	.288	.318	.188	.173
9-12	—	.246	—	.508	—	.450	—	.346
	.035	.231	.088	.392	.155	.250	.096	.145
	.105	.197	.202	.351	.233	.267	.213	.301
	.206	.158	.347	.253	.307	.599	.082	.184
12-15	—	.050	—	.206	—	.214	—	.199
	.010	.078	.001	.119	.056	.229	.049	.094
	.043	.082	.062	.095	.104	.098	.109	.217
	.071	.075	.225	.140	.171	.112	.034	.099
15-18	—	.023	—	.033	—	.046	—	.068
	.003	.079	T(*b*)	.082	.020	.121	T	.098
	.005	.066	.028	.044	.030	.056	.069	.132
	.018	.061	.105	.078	.018	.099	.024	.076

TABLE 1—Concluded

Depth, inches	Inches from base of plant laterally							
	0-3		3-9		9-15		15-21	
18-21	—	.024	—	.005	—	.011	—	.024
	—	.065	—	.098	—	.087	—	.083
	.004	.054	.017	.045	.021	.064	.017	.105
	.010	.048	.043	.083	.016	.077	.015	.072
21-24	—	.007	—	.008	—	.009	—	.010
	—	.043	—	.066	—	.037	—	.042
	—	.049	—	.034	—	.041	—	.082
	.009	.036	.029	.035	.002	.068	.006	.089
24-27	—	.002	—	.010	—	.004	—	.006
	—	.024	—	.051	—	.014	—	.025
	—	.019	—	.031	—	.072	—	.060
	.020	.013	.004	.019	.012	.044	—	.024
27-30	—	—	—	—	—	—	—	—
	—	.033	—	.053	—	.011	—	.012
	—	.013	—	.014	—	.028	—	.036
	—	.003	—	.011	—	.032	—	.028
30-36	—	—	—	—	—	—	—	—
	—	.025	—	.024	—	.001	—	.001
	—	.012	—	.008	—	.031	—	.021
	—	.015	—	.012	—	.014	—	.024

(*a*) Weight on first sampling date. Other dates chronologically arranged from top to bottom. Dates of sampling were June 23; July 11, 15, 21 and 28; August 10 and 23; and September 11.
(*b*) Roots present but weighed less than .001 gram.

on the first sampling date in both the lateral and vertical direction from the base of the plant. This was associated with the downward and diagonal early growth of the root system and the fact that a very large proportion of the root weight existed close to the base of the plant (Table 1).

The percentage distribution lines tended to converge through the next two sampling periods indicating that considerable uniformity in root distribution occurred on the 41st day. On this date, the percentages of roots in the four areas laterally from the base of the plant were 28, 29, 21, and 22, respectively. Percentage of roots in the four layers in the upper foot of soil ranged from 20 to 25 percent. Root distribution on this date is shown in the photographs of Fig. 1.

Percentage of roots in the 3 to 6 and 6 to 9-inch layers were greater than in the 0 to 3-inch layer on the 37th, 41st, and 47th days.

Percentage of roots at various locations, laterally and vertically,

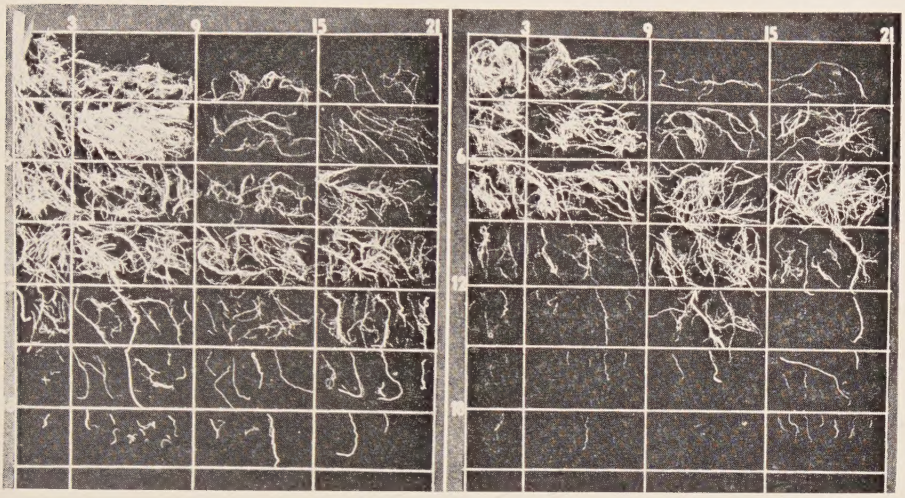

Fig. 1. Root distribution in 4-inch thick slabs of soil 41 days after planting (July 15). Sample on the left collected directly opposite the plant and on the right midway between two plants 8 inches apart.

diverged after the 41st day. Brace roots were observed to be about 1 inch long on the 47th day. Their continued growth in the upper 3 inches of soil near the base of the plant accounted for the rapid increase in the percentage of roots at these locations after the 41st day. The increase in percentage of roots in the 3- to 9-inch zone from the plant and at the 6- to 9- inch depth between the 67th and 80th day was associated with extension of brace roots into these areas.

Eighty percent of the root weight below 15 inches occurred between the 54th and 67th day (Table 1). There was a marked increase in the percentage of roots. Decreasing percentages of roots below 9 inches, between the 67th and 80th days, were associated with nearly constant weights at these depths, and root weight increases in the area of brace root development. Root distribution and weight did not change significantly after the 80th day.

Percentage distribution in 1960 was comparable to that reported for 1959 (2).

Root Distribution and Density at Maturity. It has been shown that the brace roots contributed significantly to the total root weight and that they were restricted to the upper 9 inches of soil within 9 inches of the plant. Approximately 75 percent of the total root weight occurred in this area and represented less than 10 percent of the sampling volume.

Root weight in the sample collected opposite the plant and the sample collected between adjacent plants, excluding the areas in the upper 9 inches of soil within 9 inches of the plant, was essentially the same on August 10th and the 23rd. It differed by less than 10 percent on September 12, 1960. Similar results occurred for samples collected on September 11, 1959. It is concluded that root density longitudinally down the row was homogeneous, except for the area invaded by brace roots. The photographs in Fig. 2 also support this conclusion.

Large differences in root density, laterally from the plant, existed in the upper foot of soil but varied little below this depth (Table 2). Average root density of both years, in grams per cubic foot of soil below 12 inches, was .98, .78, .67, and .68 for the 0 to 3, 3 to 9, 9 to 15, and 15 to 21-inch zones. Data reported by Fehrenbacher and Alex-

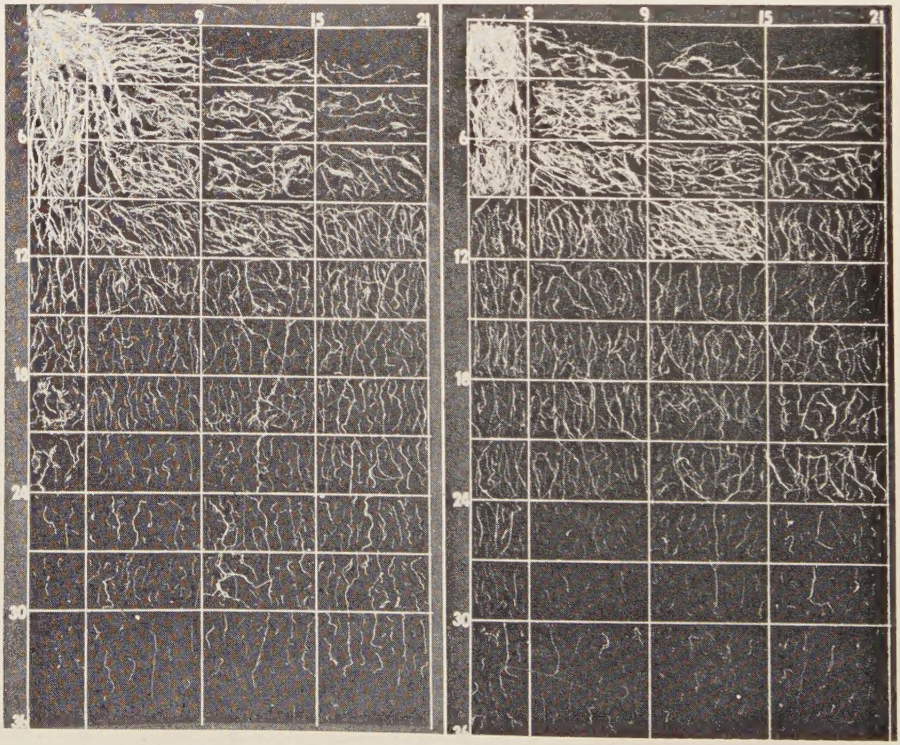

Fig. 2. Root distribution in 4-inch thick slabs of soil on the 100th day after planting (September 12). Sample on the left collected directly opposite the plant and on the right midway between two plants 8 inches apart. Note that root density in the 9-21 inch zone is greatest below the surface layer. Also note the marked uniformity of roots in all directions in the second foot of soil.

TABLE 2—Root density at maturity in grams per cubic foot of soil

Depth, inches	Inches from base of plant laterally			
	0-3	3-9	9-15	15-21
	September 11, 1959			
0-6	87.74	8.02	1.12	.44
6-12	6.04	4.59	.88	1.92
12-18	3.74	1.90	1.50	1.36
18-24	.85	1.98	1.10	1.21
24-30	.98	.37	.52	.70
30-36	.07	.43	.15	.32
36-42	.14	.08	.08	.03
	September 12, 1960			
0-3	113.35	9.55	1.01	.35
3-6	34.23	10.92	3.36	1.32
6-9	16.08	7.08	3.81	2.07
9-12	3.79	3.03	7.18	2.19
12-15	1.82	1.67	1.33	1.18
15-18	1.48	.94	1.18	.91
18-21	1.14	.99	.92	.85
21-24	.86	.41	.81	1.06
24-27	.32	.23	.52	.29
27-30	.07	.14	.38	.35
30-36	.18	.07	.08	.14

ander (1) show this same trend, but to a lesser degree for corn grown in hills. They showed that the average root weight in cores 4 inches in diameter to a depth of 6 feet was 1.72, 1.70, and 1.23 grams for the 8 to 12, 12 to 16, and 16 to 20-inch distances from the hills spaced 40 inches apart.

In a somewhat related problem, Weaver and Voight (5) found that root distribution was remarkably uniform below a depth of 3 inches in a bunch grass prairie. Field observations made during the study support the view that the uniformity in root density laterally below 1 foot was associated with the distribution of voids caused by soil structure, channels formed by earthworms, and roots of previous crops.

Root density ranged from 113 near the base of the plant to 1/10 or less below 30 inches (Table 2). Root density varied with distance

from the plant and decreased with depth within 3 inches of the plant. At the 9 to 15 and 15 to 21-inch distances from the plant, maximum root density occurred in the 9 to 12-inch layer in 1960 and occurred similarly below the surface layer in 1959 (Fig. 2 and Table 2).

Maximum root weight in the 9 to 21-inch zone never occurred in the top 3 inches of soil on any of the 8 sampling dates (Table 1). Sixty-five percent of the total root weight was in the upper 6 inches of soil, compared to only 19 percent for the area in 9 to 21 inches from the plant in 1960. In 1959, these percentages were 68 and 14, respectively.

Root density decreased slowly in a vertical direction in the second foot of soil (Table 2). It has been shown that root density below 12 inches was little affected by distance from the plant laterally. Therefore, root density in the second foot of soil was remarkably uniform in all directions, except for a very gradual decrease laterally from the plant and a gradual decrease vertically (Fig. 2). It would have required only a small decrease in the average root diameter, with increasing distance from the plant, to cause the second foot of soil to be isotropic with respect to root surface area.

Root density in the third foot of soil was only about one-fifth as great as in the second foot of soil (Table 2).

Root Weight. Root weight at maturity was 25.6 grams per plant, or 1,054 pounds per acre, for a plant spacing of 8 inches between plants in 42-inch rows. Results reported for 1959 were 28.8 and 1,186, respectively (2).

SUMMARY AND CONCLUSIONS

Percentage distribution of roots laterally and vertically from the base of the plant for eight dates in 1960 were discussed.

Root density at maturity was (a) homogeneous longitudinally down the row, except for the area invaded by brace roots, (b) greatest below the surface layer in the zone 9 to 21 inches from the plant, (c) remarkably uniform in all directions between 12 and 24 inches, and (d) importantly affected in a lateral direction below 12 inches by the voids between aggregates, channels formed by earth worms, and the roots of previous crops.

It is concluded that the data (a) will permit the development of more efficient root sampling procedures from the standpoint of time and location of sampling, and (b) suggest that the plant utilized the

soil below the surface layer with similar efficiency, irrespective of lateral distance from the plant. Additional studies are needed to evaluate the extent to which response to plant spacing, at constant population, is the result of changes in soil utilization efficiency and to changes in above ground environment.

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CONTROL OF BACTERIAL SPOT AND OTHER FRUIT AND FOLIAGE DISEASES OF TOMATOES

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In the past five years, a disease called bacterial spot (caused by *Xanthomonas vesicatorium*) has become a serious hazard in production of the tomato crop. Both foliage and fruit are attacked. When leaves are infected, some defoliation may occur with resulting reduction in yield. The green fruits are infected with an irregular, black, scab-like spot, about ⅛ to ¼ inch in size (see Fig. 1). Several of these spots may coalesce to form a scabby area. Infected fruit are down graded and usually unsalable. Peppers are also susceptible and display similar symptoms.

The causal organism may be carried on the seed and also live over winter in the soil where an infected crop has been grown. The seed borne infection may be controlled by a seed treatment with Ceresan M dust at ½ percent by weight of seed. However, a spray program is necessary to control soil borne infection, which is spattered by rain onto the plants.

Bacterial spot is not a new disease. Rather, it is one that has become more of a problem since the advent of organic fungicides. This has resulted in omission of copper fungicides, with their bactericidal action, from many tomato spray programs. Since the object of the tomato spray trials in Michigan has been to develop a spray program which would control as many of the leaf and fruit diseases as possible with the least cost, experiments on the control of bacterial spot were undertaken four years ago.

Agrimycin 500, a fungicide containing both copper and the antibiotic Streptomycin, was tested in 1957-58.[2] This material provided

[1]The author wishes to thank the agricultural chemical companies that furnished materials and financial aid for these tests.

[2]Strong, M. C. (1959) Fungicidal spray trials on tomatoes, 1957-58. Mich. Agr. Expt. Sta. Quart. Bul. 41: 853-858

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Fig. 1. Bacterial spot infection on tomato fruit.

excellent control of late blight, but during these tests, bacterial spot failed to develop in the plots even after attempts at inoculation with cultures of the bacteria.

The tests herein reported were conducted in the same field and same manner as previously described.[3] The tomato variety planted in 1959 was Garden State and in 1960, Campbell's 146. Each season, six spray applications were made at approximately 10-day intervals, beginning when the first fruit was about 1½ inches in diameter. An insecticide (Methoxychlor in 1959 and Dieldren in 1960) was added to the first two spray applications. The control plants were sprayed with insecticide alone.

In 1959, the bacterial spot inoculations failed to produce any disease, due perhaps to the hot, dry season. Late blight was also absent, but early blight, *Septoria* blight, and anthracnose were abundant.

In 1960, the bacterial spot inoculations were done after sundown.

[3] ..... (1950) Comparison of fungicidal sprays for the control of tomato blights. Mich. Agr. Expt. Sta. Quart. Bul. 32: 338-347

The plants were first dampened by 10 minutes of overhead irrigation. Then, suspensions of the causal bacterium were sprayed on the plants. This procedure was followed every evening until all the plots had been inoculated. A fairly heavy infection of bacterial spot was developed in this way. The nightly irrigation also increased the early blight, *Septoria* blight, and anthracnose infection. Late blight was not present, there being no prevailing source of inoculum.

The results of the 1959 spray trials are shown in Table 1 and those of 1960 in Table 2. On the basis of marketable yield, the best spray applications tested were Zineb plus COCS,[4] Miller 658[5] plus Ziram, Miller 658 plus Maneb, Niacide M[6] plus COCS, TC 11,[7]

[4]COCS is copper oxychloride sulfate (55% metallic copper).
[5]Miller 658 is copper zinc chromate (29.6% metallic copper).
[6]Niacide M contains 48% manganous dimethyldithiocarbamate, 12.4% tetramethyl thiuram disulfide, 2.4% manganous benzothiazyl mercaptide and 2.2% 2-2 dithiobisbenzothiazole.
[7]TC 11, 22 and 90 are different formulations of a liquid copper.

TABLE 1—Summary of 1959 tomato fungicidal spray trials

Treatment	Rate of application	Total marketable yield tons per acre	Percentage defoliation September 16, 1959
Zineb+COCS(*a*)	1½ lb.+1½ lb.—100 gal.	15.5	15.0
Miller 658(*b*)+Maneb	1½ lb.+2 lb.—100 gal.	15.4	15.5
Niacide M(*a*)+COCS	1½ lb.+1½ lb.—100 gal.	15.3	12.5
TC 11(*c*)	1 gal.—100 gal.	15.1	10.7
Phaltan(*d*)	3 lb.—100 gal.	15.0	20.0
Miller mix(*b*)+Streptomycin	2 lb.+100 ppm—100 gal.	14.9	16.0
Miller mix(*b*) (658+Ziram)	1 lb.+1 lb.—100 gal.	14.7	15.2
Niacide M mix (M+COCS)(*a*)	3 lb—100 gal.	14.5	12.5
TC 11+Niacide M	1 gal.+1½ lb.—100 gal.	14.1	15.2
Niacide Z mix (Z+COCS)(*a*)	3 lb.—100 gal.	13.9	21.0
Maneb	3 lb.—100 gal.	13.9	21.3
Niacide Z(*a*)+COCS	1½ lb.+1½ lb.—100 gal.	13.6	22.5
TC 11+Maneb	1 gal.+1½ lb.—100 gal.	13.4	17.5
Mathieson 1763-2(*e*)	2 lb.—100 gal.	13.1	30.0
TC 22(*c*)	⅓ gal.—100 gal.	12.0	15.5
TC 22+Maneb	⅓ gal.+1½ lb.—100 gal.	11.9	13.0
Mathieson 1763-1	1 lb.—100 gal.	11.8	42.0
TC 22+Niacide M	⅓ gal.+1½ lb.—100 gal.	11.3	12.5
Mathieson 2398-1(*e*)	1 lb.—100 gal.	10.7	45.5
Mathieson 2398-2	2 lb.—100 gal.	10.6	40.0
Control	No treatment	7.5	60.5
L.S.D. (1%)		.8	5.5

(*a*) Products of Niagara Chem. Div., Food Machinery and Chemical Corp.
(*b*) Products of Miller Chemical and Fertilizer Corp.
(*c*) Experimental liquid coppers of Tennessee Corp.
(*d*) Product of California Spray Chemicals Company.
(*e*) Experimental Products of Olin Mathieson Corp.

TABLE 2—Summary of 1960 tomato fungicidal spray trials

Treatment	Rate of Application	Total marketable yield tons per acre	Percentage defoliation August 30, 1960
Miller 658(*a*)+Ziram	2 lb.+1½ lb.	17.2	17.5
Miller 658+Ziram	1½ lb.+1½ lb.	17.0	25.0
Niacide M(*b*)+COCS(*b*)	1½ lb.+1½ lb.	16.9	25.0
Cupric omadine (1562)(*c*)	2 lb.	16.8	25.0
TC 90 (liquid copper)(*d*)+ Dyrene(*e*)	1 gal.+1½ lb.	16.7	30.0
Niacide M	3 lb.	16.6	35.0
Maneb+COCS	1½ lb.+1½ lb.	15.9	27.5
Phaltan(*f*)+ML481(*b*) (copper)	1½ lb.+2 lb.	15.7	27.5
Miller 658+Ziram+Streptomycin	1½ lb.+1½ lb.+100 ppm.	15.5	25.0
Phaltan	3 lb.	15.0	32.5
TC 90	1.25 gal.	14.8	42.5
TC 90	2 gal.	14.5	35.0
Tribasic copper sulfate(*d*)	4 lb.	14.4	30.0
Maneb	3 lb.	14.3	37.5
Ferric omadine (1565)(*c*)	2 lb.	14.0	35.0
TC 90+Phaltan	1 gal.+1½ lb.	13.9	32.5
Dyrene	3 lb.	13.5	37.5
TC 90	.75 gal.	11.0	57.5
Control untreated		6.8	90.0
L.S.D. (1%)		.5	7.5

(*a*) Product of Miller Chemical and Fertilizer Corp.
(*b*) Product of Niagara Chem. Div. Food Machinery and Chemical Corp.
(*c*) Product of Olin Mathieson Corp.
(*d*) Product of Tennessee Corp.
(*e*) Product of Chemagro Corp.
(*f*) Product of California Spray Chemicals Corp.

Cupric omadine,[8] TC 90 plus Dyrene[9] and Phaltan[10] plus copper ML481.

On the basis of control of defoliation, superior spray treatments were Zineb plus COCS, Miller 658 plus Ziram, Miller 658 plus Maneb, Niacide M plus COCS, Niacide M plus TC 11, and Niacide M plus TC 22. It was impossible to determine how much defoliation was due specifically to early blight, bacterial spot, or *Septoria* blight.

Table 3 shows the 1960 fruit infection record with bacterial spot and anthracnose, and stem and calyx infection with *Septoria.*

Copper fungicides used alone, or in combination with organic fungicides, provided the best control of bacterial spot, while the sprays not containing copper failed to control this disease. The addition of Streptomycin (100 p.p.m.) to Miller 658 plus Ziram did not

[8]Cupric omadine is the cupric salt of 2-pyridine thione-1-oxide.
[9]Dyrene is 2, 4-dichloro-6 0-chloroanilino-5-triazine (50% W.P.).
[10]Phaltan is N-trichloro methyl-thio-phthalimide (50% W.P.).

TABLE 3—1960 tomato infection record

	Bact. spot (fruit)	Anthracnose (fruit)	*Septoria* (stem-calyx)
Miller 658 (2 lb.)+Ziram	sl	0	0
Miller 658 (1½ lb.)+Ziram	0	0	0
Miller 658 (1½ lb.)+Ziram+Streptomycin	0	0	0
Cupric omadine	sl	sl	0
Ferric omadine	++	+++	++
Phaltan	[illegible]	[illegible]	[illegible]
Phaltan+ML481 Copper	0	+	0
Tribasic Copper Sulfate	sl	++++	++
TC 90 (.75 gal.)	+	++++	++++
TC 90 (1.25 gal.)	sl	++++	++
TC 90 (2.00 gal.)	0	++++	+
TC 90 (1.00 gal.)+Phaltan	sl	+	+
Dyrene	+++	+	++
Dyrene+TC 90 (1 gal.)	sl	0	0
Niacide M	+++	0	++
Niacide M+COCS	0	sl	0
Maneb	+++	+	+
Maneb+COCS	0	sl	0
Control (untreated)	++++	++++	++++

0 = no infection.
sl = slight infection.
+ to ++++ = increasing infection.
++++ = nearly all plants infected.

increase the effectiveness of this spray combination in the control of bacterial spot. Since Streptomycin may only be applied to tomatoes prior to fruit set (F.D.A. ruling) and experience has shown that control applications are often necessary later in the season than that, this antibiotic was omitted from the other spray combinations tested.

The best control of anthracnose was obtained by applications of Miller 658 plus Ziram, Cupric omadine, Niacide M alone or plus COCS, Dyrene plus TC 90, Maneb alone or plus COCS.

Effective control of *Septoria* blight resulted from combined applications of organic fungicides and coppers, or from the copper-containing organic compound, Cupric omadine.

Conclusions

It is evident from the results of these experiments that combinations of various copper fungicides with organic fungicides offer the best control of early blight, *Septoria* blight, bacterial spot, and anthracnose. Such spray combinations tested were Zineb plus COCS, Niacide M plus COCS, Miller 658 plus Maneb, and Miller 658 plus Ziram. TC 90 plus Dyrene, Phaltan plus copper ML 481, and Cupric omadine showed considerable promise in the 1960 trials.

SOIL pH IN RELATION TO DIFFERENT LIMING MATERIALS APPLIED TO AN APPLE AND A PEACH ORCHARD

By S. J. GAMBLE and A. L. KENWORTHY[1]

DEPARTMENT OF HORTICULTURE

LIMING, AS APPLIED TO AGRICULTURE, is the adding to soil of any compound containing calcium or calcium and magnesium that is capable of reducing the acidity of the soil. For many years, liming has been a standard practice in Michigan, since most soils continuously increase in acidity due to natural processes. The additional need for lime in orchards that have been sprayed over a period of years with acid-forming materials has been shown by Embleton and Boynton (4).

Porter *et al.* (8) made recommendations concerning rates for applying lime to various Michigan soils; however, little information was offered concerning the time necessary to bring about the desired change, the time the material could be expected to remain effective, depth to which it would penetrate, etc. In Maryland, Hoyert and Axley (5) recommended higher lime applications than the Michigan workers to attain the same pH change for a given soil. However, Michigan recommendations have recently been revised and increased by Longnecker (7) who based them on a specific material.

Longenecker and Merkle (6) reported that liming materials should be incorporated into the soil, while Sell and Olson (10) and Brown *et al.* (3) indicated that a single surface application on a sod could influence the pH to depths of up to 30 inches, depending on rate of application and time. MacIntire (8), Beacher and Merkle (1), and Beacher *et al.* (2) investigated the effects of composition of material and particle size and found them to be major factors in determining the resulting pH change.

A variety of liming materials is available in Michigan fruit growing areas. Little information has been available to growers concerning

[1]The authors express appreciation to the various companies who supplied the materials used and to Drs. W. W. McCall, R. P. Larsen, and D. R. Dilley who assisted in applying the materials.

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the effectiveness of these products in relation to the method of application, depth to which the material is effective, and the required time for the various materials to become effective as neutralizers.

The purpose of this study was to determine the relative efficiencies of various liming materials currently available in Michigan, as determined by their effectiveness in changing pH values of orchard soils at various depths over a period of time.

Description of Materials

Eight liming materials commonly used in Michigan orchards, or available for use, were compared in this study. They consisted of four calcic and four dolomitic products of various forms and particle sizes. Table 1 describes these materials.

Methods

In 1954, materials listed as numbers 3, 4, 7 and 8 in Table 1 were applied at the rate of 2 tons per acre to a mature apple orchard

TABLE 1—Liming materials available for use in Michigan orchards(a)

Material	Source	Composition	Particle size	Neutralizing value
1. Calcic limestone (coarse meal)	Cheny Limestone Co., Bellevue	$CaCo_3$ approx. 83%	27% thru 100 mesh 98% thru 8 mesh	85%
2. Calcic lime (hydrated)	Carrier Stephens Co., Lansing "Mississippi brand" hydrated spray lime	$Ca(OH)_2$ 96-100%	96% thru 325 mesh	130-135
3. Dolomitic limestone (fine meal)	Drummond Island—various dealers	$CaCo_3$ 54% $MgCO_3$ 44%	34% thru 100 mesh 66% thru 40 mesh 98% thru 8 mesh	104
4. Dolomitic limestone (agricultural pulverized)	National Gypsum Co. "Gold Bond" brand	$CaCO_3$ 54% $MgCO_3$ 44%	75% thru 100 mesh 100% thru 40 mesh	106
5. "Dolomite Dust"	Standard Lime and Cement Co., Lawton	$CaCO_3$ 53.5% $MgCO_3$ 43.5%	71% thru 100 mesh 90% thru 40 mesh 98% thru 8 mesh	102-105
6. Dolomitic limestone (agricultural hydrated)	National Gypsum Co. "Gold Bond" brand	$Ca(OH)_2$ 54% $Mg(OH)_2$ 43.5%	98% thru 200 mesh	152
7. Acetylene by-product	Union Carbide Olefins, Montague	$Ca(OH)_2$ (impure)	100% thru 100 mesh	120
8. Blast furnace slag (water granulated)	Ag-Granulite Slag Co., 500 Washington St., Chicago, Ill. (produced by Inman Steel Co., So. Chicago, Ind.).	$CaSiO_3$ +7% Fe traces Mo, B	4% thru 100 mesh 26% thru 40 mesh 97% thru 8 mesh	87

(a) The materials used in this study were obtained from the source indicated. Data on composition, particle size and neutralizing value were obtained from the department of soil science, Mich. State Univ.

growing in sod. In 1956, materials 1 thru 6 were applied at the same rate to a mature peach orchard that was under a clean cultivation system of soil management.

In 1959, 3 years after lime application, the soil in the plots was sampled. A Hoffer sampling tube was used to obtain cores 12 inches deep, which were divided into the surface 6 inch and the 6- to 12-inch portions.

pH values were determined with a Beckman Zeromatic pH meter, according to methods used in the Soil Testing Laboratory, Department of Soil Science, M. S. U.

Results and Discussion

The results obtained from the peach and apple orchard lime plots are given in sections A and B of Table 2. The various forms of lime are listed in order of their relative effectiveness.

All liming treatments made in the peach orchard exerted a significant effect on the pH of the surface 6 inch horizon within 3 years after application, while apparently only the hydrated dolomitic limestone moved into the 6- to 12-inch horizon.

Five years after applying lime treatments in the apple orchard, three of the four materials evaluated had affected significantly the pH of the soil in the surface 6 inches. Acetylene by-product was the only material that significantly affected pH in the 6- to 12-inch level as well as the surface 6 inches. These materials had been applied on the surface of a sod and had not been incorporated into the soil by cultivation.

The results of this comparison may be explained by referring to the information given in Table 1. The materials varied widely in solubility and particle size, since some were in a naturally fine and soluble hydroxide form, while others were coarser and less soluble carbonates. Since the calcium and magnesium ions must first be in solution in order to replace the hydrogen ions on the soil particles, it is obvious that the hydroxide materials should neutralize acid soil conditions more rapidly than the carbonates. Among the carbonates, the finely ground materials were more effective than the popular "meal" grade. The extent of neutralization is indicated by the magnitude of the pH change.

A second factor affecting the amount of change in pH is the neutralizing value of the material. Since it is the primary ingredient

of limestones, calcium carbonate is used as the basis for comparison, and is given a neutralizing value of 100. As may be seen in Table 1, the neutralizing values of the hydrates and acetylene by-product, which are hydroxide forms, were higher than the carbonates. In addition, since magnesium has a greater neutralizing power than calcium, the dolomitic hydrates may be expected to be more effective than calcic hydrates. Tables 1 and 2 show that the materials were effective in the order of their relative neutralizing values.

These results indicate that a more effective means of neutralizing soil acidity is afforded by the hydroxide forms of liming materials than by the carbonates. Table 2 indicates that the greater neutralizing effect of the hydroxides was present for at least 3, and possibly 5, years after application.

Since magnesium is generally needed in Michigan apple orchards, a dolomitic limestone would supply this requirement. A hydrated form, although more expensive, may be a more favorable choice than a carbonate.

TABLE 2—Soil pH changes resulting from lime applications in orchards

A. Changes in pH in a peach orchard resulting from liming 3 years previously. Application rate: 2 tons per acre (numbers preceding treatment materials refer to listing in Table 1).

Treatment	0-6 inch depth	6-12 inch depth
Check—no lime	4.6	4.6
6. Hydrated dolomite	7.0**	5.5*
2. Hydrated calcic	6.8**	4.9
4. Pulverized dolomite	6.1**	4.8
5. "Dolomite Dust"	5.7**	4.6
6. Drummond Island dolomite	5.4**	4.8
1. Calcic limestone	5.2**	4.5

B. Changes in pH in an apple orchard resulting from liming 5 years previously. Application rate: 2 tons per acre.

Treatment	0-6 inch depth	6-12 inch depth
Check—no lime	4.3	4.6
7. Acetylene by-product	6.2**	5.2**
3. Drummond Island dolomite	5.1**	4.6
4. Pulverized dolomite	4.8**	4.6
8. Blast furnace slag	4.4	4.5

*Treatment significant at 5 percent level.
**Treatment significant at 1 percent level.

Summary

Eight liming materials were compared by making surface applications at the rate of 2 tons per acre in commercial orchards in 1954 and 1956. Soil samples were taken in 1959 and tested for pH according to standard methods.

Results indicated a greater effectiveness of the materials composed of dolomitic limestones in the hydroxide form. After 3 and 5 years, the hydroxide materials remained more effective as acid neutralizers than the carbonate materials. The importance of the dolomitic form of limestone was indicated by noting that the order of effectiveness was related to the neutralizing values.

It is suggested that dolomitic hydrate, since it supplies the nutrient element magnesium, and is a most effective neutralizer of soil acidity, should be the major liming material used in Michigan orchards.

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HEALTH ORGANIZATIONS IN THE LANSING COMMUNITY

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Health is a subject of concern to people in many different ways. Almost everyone is interested in personal health, but often an individual's interest will extend beyond the personal realm. It will be expressed in organization membership and activities which are designed to promote health and health care. Usually health organizations develop for the purpose of combating a particular disease or for dealing with a specific health problem. Such organizations seek support from the population in a particular community, though they do not duplicate one another in their objectives. It has been observed also that the number and variety of voluntary health organizations increase with the size of the community.

Purpose of Study

The foregoing observations have produced many questions about the nature and purpose of health organizations. For example, what purposes or objectives do health organizations try to attain? Do they enlist the interest of only a few persons from the total community as officers and board members? Do certain organizations appeal to only a small segment of the community? Are the organizations that develop purely local in nature or do they represent affiliations with state and national organizations? From what sources do voluntary health organizations receive their financial support? What geographical area do they serve? Do they confine their activities to the central city of the community or do their services include the suburban and rural areas as well? The foregoing are some of the questions which come to mind as one thinks about health organizations in a metropolitan type of community. The search for answers to these and related questions became the purpose of the research reported in the following paragraphs.

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Method of Study

The method of study used in this research was the survey method. A representative of each organization that was selected for study was interviewed.[1] This included a total of 13 voluntary organizations that were located in the City of Lansing in 1959, plus three organizations that were supported by public funds. There were many more organizations in the community concerned with health and health care such as hospitals, nursing homes, and certain clinics. These were not included in the survey because they represent a different type and purpose of organization. The organizations to be included in this investigation were restricted to those which were voluntary in nature or were optionally supported by government in contrast to organizations or agencies which were supported wholly or in part by direct charge for services. The sample was further restricted to organizations which emphasized public health interests and health education.

The community selected for study was Lansing, Michigan, a city having a population of approximately 110,000 in 1960 within its corporate limits, and an estimated additional 87,000 people living in the metropolitan areas surrounding the city. This metropolitan area is surrounded by some suburban developments and rural areas.

Name and Major Purposes of the Organizations Studied

Following is the name and major purposes of the voluntary organizations included in the study as reported to the interviewer.

Organizations	Major Purposes
Dental Health Committee of Greater Lansing	Dental care of indigent children and education to need for dental care.
United Cerebral Palsy Association of Lansing	Work for cerebral palsied children and their parents. Sponsors day camp for cerebral palsied children.
Ingham County Tuberculosis and Health Society	Fund raising, public education, promotion of research and encouragement of case findings activities.
Lansing Hearing and Speech Center	Speech and hearing therapy and correction.
National Foundation for Infantile Paralysis – Ingham County Chapter	Fund raising, payment for treatment of indigent infantile paralysis victims. Dissemination of information to public, physicans and welfare agencies.

[1]Representatives of these organizations were interviewed by Gary King, graduate student in the department of sociology and anthropology at Mich. State Univ.

Organizations	Major Purposes
American Red Cross	Home services to service men and their families. Training programs in first aid. Blood bank program. Disaster relief. Responsible for Junior Red Cross, volunteer nursing service groups and nursing.
Ingham County Cancer Society	Raise funds, grant research money, locally and nationally, loan closet, dressings.
National Cystic Fibrosis Research Foundation—Ingham County Chapter	Fund raising and public education
Ingham County Society for Crippled Children and Adults, Inc.	Medical payment rehabilitation, equipment loan for crippled children and adults.
United Community Chest of Ingham County, Inc.	Raise, distribute, supervise expenditure of funds, for health and welfare.
Greater Lansing Association for Mentally Retarded Children (Institutions group)	Public education, provide place for parents to gather to discuss mutual problems.
Greater Lansing Association for Mentally Retarded Children (School group)	School for mentally retarded children.
Muscular Dystrophy Association, Ingham County Chapter	Patient service, equipment, etc. Promotion of research and public education to make public aware of disease and its effects.

The organizations supported entirely or in part by public funds included in the survey were:

Ingham County Health Department	Sanitation, inspection, communicable disease control. School health services, public health nursing. Health education for public.
Ingham County Chest Hospital and Clinic	Treatment of T.B. patients, case findings and rehabilitation, health care.
Lansing Mental Health Center	Diagnosis and treatment of adult mental health problems. Promotion of preventive mental health in the community.

The outstanding characteristics of these organizations from the standpoint of their purposes is the fact that they tend to be specialized. This is particularly true for the organizations that depend upon voluntary contributions for financial support, but the public (tax)

supported agencies tend to be specialized in purpose also. Since these organizations are specialized, they generally appeal to only a part of the population in a community.

The foregoing listing of purposes in connection with each voluntary organization gives the general objectives of the organization. In order to find out in greater detail what the organization did in the fulfillment of their objectives, each voluntary organization was asked what activities it carried out in the course of a year. The replies to this question are summarized in Table 1.

TABLE 1—Selected activities of voluntary health organizations in the Lansing community, 1959

Organization	General meeting	Lectures	Exhibits	Pamphlets(a)	News items	Movies	TV Presentations
Dental Health Committee of Greater Lansing	9	..	..	1	10	..	5
United Cerebral Palsy Association of Lansing	6	..	..	4	5	..	..
Ingham County Tuberculosis and Health Society	..	12	15	30	25	15	30
Lansing Hearing and Speech Center	..	20	..	20	20	10	20
National Foundation for Infantile Paralysis—Ingham County Chaper	12	12	10(a)	10(a)	25	25	35
American Red Cross	2	50	5	8	375(a)	10	375(a)
Ingham County Cancer Society	4	10	3	25(a)	100	75	100
National Cystic Fibrosis Research Foundation	12	3	2	3	2	12	3
Ingham County Society for Crippled Children & Adults, Inc.	6	..	..	1	35	..	25
United Community Chest of Ingham County, Inc.	12(b)	..	..	5	50	..	25
Greater Lansing Association for Mentally Retarded Children (Institutions group)	16	4	2	..	20	5	5
Greater Lansing Association for Mentally Retarded Children (School group)	9	40	3	5	15	..	10(c)

(a) Estimated number of different kinds of pamphlets distributed. The total number handed out was in the thousands.
(b) Board meetings.
(c) Includes some radio broadcasts.

Table 1 does not include all types of activities that the organizations engaged in, but does present the principal ones. The deduction which seems logical from the data in Table 1 is that, even though the organizations had specialized purposes, they tended to use similar methods in trying to attain their objectives. One activity; namely, holding a clinic, does not appear in the table. However, the following voluntary organizations did hold one or more clinics during the year: Dental Health Committee of Greater Lansing, and the American Red

Cross.[2] In total, the programs of these organizations constitute a major contribution in education about health and health care in the Lansing community.

It has been stated that in smaller communities such organizations would not be likely to exist because there would not be enough people interested in different types of specialized activities to support them. Some proof of this conclusion is evident when the number of voluntary organizations in the Lansing community is compared with a similar list compiled for the city of Jackson. Jackson had a population of 51,088 in 1950, whereas the population of Lansing in 1950 was 92,129. Jackson had only 8 voluntary health organizations comparable to the list of 13 for Lansing. In the smaller towns and villages surrounding Jackson, there were no voluntary organizations designed specifically for health purposes except a health council in the northwest part of Jackson county.[3]

Area of Service

The lack of specialized health organizations in the smaller communities and rural areas raises the question, "Do the residents in such areas receive services from organizations located in the larger center or do they lack such services and benefits entirely?" When the organizations in the Lansing community were interviewed, inquiry was made regarding the area of service.
Following are the results of this inquiry.

Organization	Reported Area of Service 1959
Dental Health Committee	Lansing metropolitan area (but primarily Lansing)
United Cerebral Palsy Association of Lansing	Tri-county area (but principally Lansing and Ingham county)[4]
Ingham County Tuberculosis and Health Society	Ingham county
Lansing Hearing and Speech Center	Greater Lansing area
National Foundation for Infantile Paralysis – Ingham County Chapter	Ingham County cooperates with surrounding county chapters
American Red Cross	Ingham County, fringes of surrounding counties

[2]Two publicly supported agencies—the Ingham County Health Department and the Ingham County Chest Hospital and Clinic reported clinics. The publicly supported agencies were not included in Table 1.

[3]Hoffer, Charles R. (1959). Organizations and services for health care. Mich. State Agr. Expt. Sta., Quart. Bul. 42: 1, pp. 210-231.

[4]Lansing is located in the northwest corner of Ingham County and is thus close to Clinton County on the north and Eaton County on the west.

Organization	Reported Area of Service 1959
Ingham County Cancer Society	Ingham County, fringes of surrounding counties.
National Cystic Fibrosis Research Foundation, Ingham County Chapter	Ingham County. Some members from Clinton and Eaton Counties (work mostly in Lansing)
Ingham County Society for Crippled Children	Ingham County. Mostly from Lansing. (2 patients from Williamston, 5 or 6 from Holt, 3 from Mason, 1 from Stockbridge)
United Community Chest of Ingham County, Inc.	Ingham County. Parts of Clinton and Eaton Counties.
Greater Lansing Association for Mentally Retarded Children (Institution group)	City of Lansing
Greater Lansing Association for Mentally Retarded Children (school group)	Lansing. Some communities in Clinton and Eaton Counties represented.
Muscular Dystrophy Association, Ingham County Chapter	Ingham County, mostly Lansing, Clinton and Eaton Counties represented.
Ingham County Health Department	Ingham County
Ingham Chest Hospital and Clinic	Ingham County, surrounding counties. Surgery for U.P. and Muskegon County Sanatoria, T.B. patients for 7 other counties that have no sanatoria.
Lansing Mental Health Center	Approximately 75 percent of patients from Lansing area. The remainder from surrounding community chests.

A rough tabulation of the information about the principal area of service showed the following distributions:

Area	Number of Organizations
City of Lansing	2
Lansing Metropolitan Area	7
Ingham County	6
Tricounty Area	1

It seems evident on the basis of this tabulation that most of the organizations in the City of Lansing do in fact extend their activities beyond the corporate limits of the city. Consequently the question, "Do residents living outside the corporate limits of a city tend to receive the services of specialized health agencies?", can, on the basis of the information received from Lansing organizations, be answered affirmatively. Almost half of the organizations extended services to

the metropolitan area and six out of a total of 16 considered their area of service to be the entire county (Ingham) in which Lansing is located. Most of the six had the word "county" in the name.

Two plans of organization seem to be evident in these tabulations. One may be designated as the trade area or metropolitan area plan. Following this plan the area of organization tends to be coterminous with the shopping area of the center. Seven of the 16 organizations are so organized. This plan seems to be effective when the support of the organization depends upon voluntary contributions. The organization gains whatever advantage the identification with the trade center may have for it.

The second plan of organization that is evident is to designate a political unit as the area of service. Usually this unit is the county because other political areas are unsuited for organization purposes. The town or city only does not include its trade area and a township area is too small. Three of the organizations had the word county in the name and three used the county as the local unit of organization.

Number of Persons Identified With the Organization

The question which logically arises at this juncture pertains to the nature of the membership of the various organizations. It can be stated as an hypothesis that the more specialized the interest or objectives of the organization become, the smaller will be the membership (or other forms of identification with the organization). Even membership itself varies in intensity from merely paying dues or making contributions to attendance at meetings, acting as a committee member, serving as a board member or being an officer. The information about this characteristic of the organization is shown in Table 2.

There is evidence in the information contained in Table 2 that organizations with specialized programs which appeal to only a limited number of people tend to have a small membership. Examples of organizations of this type would be the Muscular Dystrophy Association or the Greater Lansing Association for Mentally Retarded Children. On the other hand, if an organization is concerned with a specialized interest which concerns the public in general its membership (or other ways of identifying with it) will be large.

Good examples of organizations of this type are the Ingham County Tuberculosis and Health Society and the Ingham County

TABLE 2—Nature of membership and place of residence of officers and board members of voluntary health organizations in the Lansing community, 1959

Organization	Nature of membership	Residence of officers and board members
Dental Health Committee of Greater Lansing	10-25 persons (dentists, nurses, and delegates from other organizations)	Lansing, officers only
United Cerebral Palsy Association of Lansing	60-65—Most parents of children having cerebral palsy	Lansing and Okemos in Ingham County
Ingham County Tuberculosis and Health Society	38,418 contributors who filled out membership cards. (There were many who did not)	Lansing, East Lansing and in Ingham County, Holt, Williamston, Stockbridge, and Mason
Lansing Hearing and Speech Center	75 dues paying members	Lansing, East Lansing, Okemos, Ingham County and Grand Ledge in Eaton County
National Foundation for Infantile Paralysis—Ingham County Chapter	59—Board members	Lansing, East Lansing. Elsewhere in Ingham County: Dansville, Haslett, Leslie, Mason, Okemos, and Williamston
American Red Cross	30-42 board members, 35-40 thousand contributors, and about 2,000 volunteers	Officers only—Lansing, East Lansing, Okemos
Ingham County Cancer Society	36 board members—24 to 40 thousand contributors	Lansing and in Ingham County, Holt and Williamston
National Cystic Fibrosis Research Foundation—Ingham County Chapter	15 parents of afflicted children and other interested persons	Lansing and East Lansing, St. Johns, Clinton County
Ingham County Society for Crippled Children and Adults, Inc.	30 board members, contributors, and Purchasers of Easter seals	Lansing, East Lansing, in Ingham County, Dansville, Leslie, Mason, Onondaga, Stockbridge
United Community Chest of Ingham County	36 board of directors, 25 committees	Lansing, East Lansing, in Ingham County; Mason, in Eaton County, Grand Ledge
Greater Lansing Association of Mentally Retarded Children (Institution group)	140 persons (parents and other interested persons)	Lansing, East Lansing, in Ingham County, Okemos and Mason, in Eaton County, Eaton Rapids
Greater Lansing Association for Mentally Retarded Children (School group)	100 persons (mostly parents)	Lansing, in Ingham County, Holt
Muscular Dystrophy Association, Ingham County	18 Board members	Lansing, E. Lansing, in Ingham Co., Okemos and Stockbridge

Cancer Society. The determining factor in such instances seems to be interest of the public in the purposes or program of the organization. Number of members, however, is only one indication of the importance or value of an organization to its members and to the community. The continued existence of an organization, even though its membership may not be large, is an indication of its importance.

Range of Participation of Officers and Board Members

It is obvious from the foregoing information about membership that participation on the part of members in many organizations is very slight. On the other hand, some members, such as board members, committee members, and officers participate to a very great extent. Intensity of participation of membership in general, however, was not investigated in this research. Rather the investigation was concerned with the *range* of participation as indicated by the occupations of officers and board members. Did a few individuals participate actively in many organizations or did a great many people participate? In order to answer this question, the names of officers and of board members for the various organizations (not including the three that were financed with public funds) were secured. A check was then made to see if certain names appeared in the lists for several organizations or if there was a tendency for the people to limit their participation as board members or officers to one or two organizations. The names of 316 persons were considered. Of this number, two persons were listed for as many as three organizations and 14 were listed in as many as two. This leaves an even 300 persons who were participating in only one health organization. The obvious deduction from this tabulation is that the existence of a large number of health organizations in a community tends to elicit the participations of a large number of its residents. On the basis of this evidence, it may be concluded that the presence of any particular organization does not deprive others of responsible citizen participation. However, the possible overlap of general membership in the various organizations could not be considered.

Occupation of Officers or Board Members

For some of the organizations the occupation of the officers and board members was obtainable. In fact, this information was ascertained for 81 persons. The distribution of these 81 individuals according to occupation is significant for it indicates the source of leadership for health organizations. The distribution follows:

Occupation	Number
Medical Doctor	16
Housewife	14
Business Executive	6
School Principal	5
Owner of Small Business	4

Occupation	Number
Banker	4
Dentist	3
Professor	2
Social Worker	2
Executive Director of an association	2
Labor organization representative	2
Lawyer	2
Insurance representative	2
Newspaper representative	2
Mayor	2
Minister	2
School executive	1
Nutrition Instructor in hospital	1
School nurse	1
Receptionist	1
Secretary	1
Audiologist	1
School Teacher	1
Laboratory Technician	1
Milkman	1
Farmer	1
Real estate	1

Though obviously not necessarily a representative sample, the foregoing numbers indicate a wide representation of occupations. Clearly, however, medical doctors and housewives are represented most frequently.

Place of Residence of Officers and Board Members

It seemed logical also to inquire if the officers and board members were residents of the City of Lansing or if some of them came from outside its borders. If the latter situation were true, it would constitute additional evidence that these organizations represened the metropolitan community and the county. Consequently, the information for certain of the organizations regarding the residence of board members or officers was ascertained and is presented in Table 2.

It seems clear from the information in Table 2 that for the organizations represented, there is recognition of the area surrounding the City of Lansing either on a trade area or a county basis, or on both.

Examination of the lists for these organizations showed that a majority in all instances were residents of Lansing and East Lansing. This seems logical, however, since these cities constitute the center of the metropolitan area. Nevertheless, there was at least one person represented from the following places in Ingham County: Holt, Dans-

ville, Okemos, Leslie, Stockbridge; and the following townships: Bunkerhill, Delhi, and Aurelius. The following places in adjoining counties were represented: Charlotte (Eaton County) and St. Johns (Clinton County). Thus, there is evidence of the range of influence of these organizations outside the City of Lansing.

Source of Financial Support

One question asked of each voluntary—that is, non-governmental supported organization—was the source of financial support. Did the organization depend upon an appeal to the people in the community for voluntary contributions or was it financed by dues or by other means? Or, was a combination of means of support used?

The information concerning this aspect of the study follows:

Organization	Sources of Financial Support (1959)
Dental Health Committee of Greater Lansing	Central District Dental Auxiliary, Rotary Club, and other service and civic organizations.
United Cerebral Palsy Association of Lansing	State association contributions and dues, special sales, and fund-raising events.
Ingham County Tuberculosis and Health Society	Annual sale of Christmas seals.
Lansing Hearing and Speech Center	Ingham County Community Chest, dues, contributions, and fees from services.
National Foundation for Infantile Paralysis – Ingham County Chapter	March of Dimes campaign.
American Red Cross—Ingham County Chapter	Ingham County Community Chest, contributions.
Ingham County Cancer Society	Contributions
National Cystic Fibrosis Research Foundation—Ingham County Chapter	Dues – voting members, and contributions.
Ingham County Society for Crippled Children and Adults	Sale of Easter Seals, Lily Parade, and coin containers.
United Community Chest of Ingham County, Inc.	Contributions
Greater Lansing Association for Mentally Retarded Children (Institutions group)	Dues – contributions
Greater Lansing Association for Mentally Retarded Children (School group)	Ingham County Community Chest, dues, tuition, and contributions.
Muscular Dystrophy Association, Ingham County Chapter	Contributions, special events—dances, etc.

It is clear from the information given above that most of the organizations use various combinations to get financial support. This included, in certain instances, dues, contributions from state or national organizations, or contributions from the United Community Chest of Ingham County. The three special campaigns were: annual sale of Christmas seals, annual sale of Easter seals and the March of Dimes campaign.

Plan of Organization

Inquiry was made also regarding plan of organization of each agency. The object of the inquiry was to ascertain if these various organizations were entirely local in character or if they represented local units of a state and national health organization. The results of this inquiry showed that the usual plan was for the organization to be a unit of a state and national organization. Only the Dental Health Committee of Greater Lansing reported that it was purely local in organization. It had no affiliation or relationship with any state or national organization. The National Cystic Fibrosis Research Foundation reported relationship with a national foundation but not a state organization. All the remaining privately supported organizations reported that they constituted local units of state and national organizations.

The question which logically arises at this point is, "To what extent does the local organization have autonomy or independence separate and apart from the state and national organization?" In the survey, two questions were asked which give an indication of the degrees of dependence between the local, and the state and national organization. The questions were: "Would a break in affiliational ties cause the local organization to lose its name?" and "Would such a break change your pattern of operation; your local operating procedures?" In answer to the first question, seven of the 13 voluntary organizations stated that a break in affiliations would cause the organization to lose its name. The second question, which seems more significant from the standpoint of the local community, was answered affirmatively by eight of the 13 organizations. In other words, a break in affiliation would cause a change in operations of eight organizations. Comments in answer to this question were as follows: "Probably would disturb," "would stop operating," "could not function."

A tabulation was made also to ascertain if written reports from the local organization to the state or national organization were required. The results showed that only four organizations—the Dental Health Committee of Greater Lansing, Lansing Hearing and Speech Center, the United Community Chest of Ingham County, Inc., and the Lansing Association for Mentally Retarded Children—did not make such a report.

Such dependence upon the state and national organization is evidence of a general trend in the society of the United States for the local, state and national units of social organizations to become interrelated and interdependent upon one another.

Summary and Conclusions

The study revealed that, although a great many health organizations existed in the Lansing community, they tended to be specialized in nature and hence did not duplicate one another in their objectives. Instead, the existence of many organizations indicated that a variety of interests and programs relating to health were being developed. In the development of their separate programs, however, there was a tendency for the various organizations to use similar methods. These methods consisted of meeting, lectures, distribution of pamphlets, items in newspapers, movies, and television presentations.

One part of the research concerned the ecological area served by each of the organizations, "Did the organization confine its activities to the City of Lansing only or did it extend its programs or services into the surrounding area?" Inquiries regarding this matter indicated that these organizations did include areas outside of Lansing. In some instances, this encompassed the metropolitan area only; whereas, in other instances, the county was the area of operation.

The number of people identified in some way with the organizations varied greatly. In certain instances, this identification consisted merely in making a contribution and nothing more; whereas, in other instances, identification consisted in being an officer or board member. The study revealed, however, that the participation as officers or board members was widely distributed among residents in the community. The occupation of 81 of these 316 persons was ascertained. This information showed that a wide variety of occupations was represented, but that medical doctors and housewives were most frequently reported. Inquiry regarding residence indicated that most

of the officers and board members resided in the City of Lansing, but a majority of the organizations had representation from other communities among their officers and board members.

These organizations used a variety of methods to gain financial support. Included were dues, contributions from state and national organizations, the United Community Chest, and, in a few instances, special campaigns, such as the annual sale of Christmas seals, annual sale of Easter seals, and the March of Dimes campaign. With only one or two exceptions, the organizations represented local units of a state and national organization. They were so closely affiliated with these organizations that if the relationships were severed the organization would probably go out of existence.

1957-59 SURVEY, LEAFHOPPERS OF THE EAST LANSING, MICHIGAN AREA

By J. R. HOFFMAN[1] and O. TABOADA[2]

THE IMPORTANCE OF LEAFHOPPERS as sap-sucking pests of plants is well established. The direct injury caused by their feeding will vary with population density and conditions favorable to the leafhoppers. Beyond the mere sucking of the plant juices is the ability of some leafhoppers to transmit plant virus diseases. Of somewhat lesser importance is the depletion of moisture in the plant due to the feeding of the leafhoppers. The distortion and or necrotic spots produces on the foliage where leafhoppers have fed, the excretion of honeydew, and the usually subsequent black sooty mold which occurs therein are also results of the feeding of these insect pests. Such injury becomes more important when the plants so affected are of economic or ornamental value.

Because of the virus disease spreading potential of the leafhoppers, a long term collection survey was carried out in the East Lansing, Michigan area. It was the purpose of this survey to obtain some idea of the leafhoppers present, their population levels during the year, and their distribution. Part of this survey has been previously reported upon.[15]

Technique

The technique of collecting the leafhoppers did not differ in general principle from the technique described and given in the earlier report[15]. Collections of the leafhoppers were made at about 8-day intervals from May until the fall frosts of late September to October. Collecting sites were retained unless changes had to be made due to loss of the plant life. When these changes were made, new sites were selected to be near the old site and to have a nearly similar condition to the original site where possible. The plants swept for this survey

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included *Prunus serotina*, *Crataegus* sp., *Rubus* sp., sour cherry, and grasses. Twenty-five double sweeps of about 160° of arc out and the same on return were taken with a 12-inch insect net at each location. It was possible to identify positively to species only adult leafhoppers since no satisfactory keys are presently available for the identification of immature forms of the leafhoppers.

Results and Discussion

Figure 1 on *Empoasca fabae* (Harris), the potato leafhopper, shows the result of observations on only the males of the species since no satisfactory keys are presently available to determine the females to species. *E. fabae* is a migratory leafhopper. Unable to withstand very low temperatures, this leafhopper dies out each winter in Michigan and other states with prolonged low temperatures. New generations originate in the Louisiana delta area as spring comes to this region. These leafhoppers and their succeeding generations migrate northward as conditions and food supplies become favorable for them. The appearance of *E. fabae* in Michigan each year is the result of these migrations. Relatively light populations of this leafhopper were produced in 1957 and 1958. The largest population peak represented in over 6 years of collecting occurred during August of 1959. This leafhopper usually appears in the first collections of mid to late May of each year. *E. fabae* was taken from grasses, *Prunus serotina*, *Rubus* sp., and sour cherry.

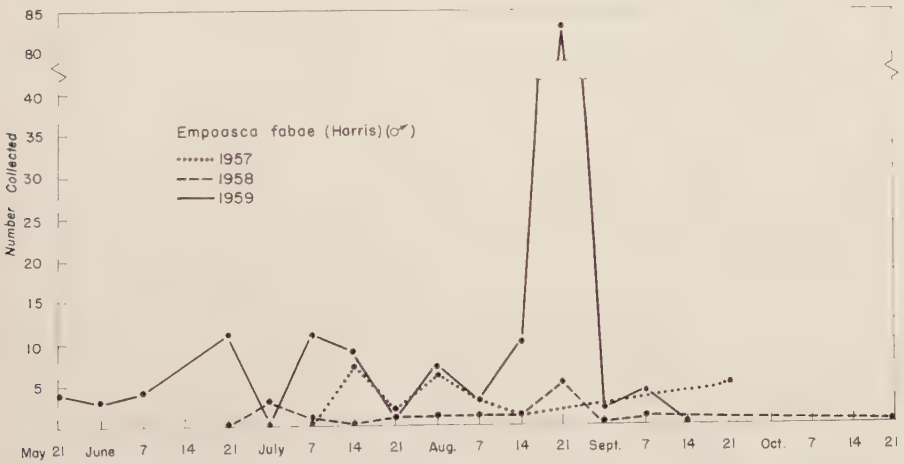

Fig. 1. Population distribution of *Empoasca fabae* (Harris), potato leafhoppers, males collected during 1957-1959.

Figure 2 shows the results of the leafhopper *Macrosteles fascifrons* (Stal) found in the collections. This species, the six-spotted leafhopper, is also migratory in much the same manner as *E. fabae*, but with its origin in the southwestern United States (probably Texas). *M. fascifrons* is the vector for the Eastern and California Aster Yellows viruses. *M. fascifrons* exhibited a certain amount of consistency in its population peaks. These occurred usually in June and then again in July to August, probably with new generations. Overall, *M. fascifrons* maintained a fairly high population level throughout the warm period of the summer and until the frosts took their toll. These leafhoppers were taken from *Prunus serotina*, *Rubus* sp., sour cherry, and grasses.

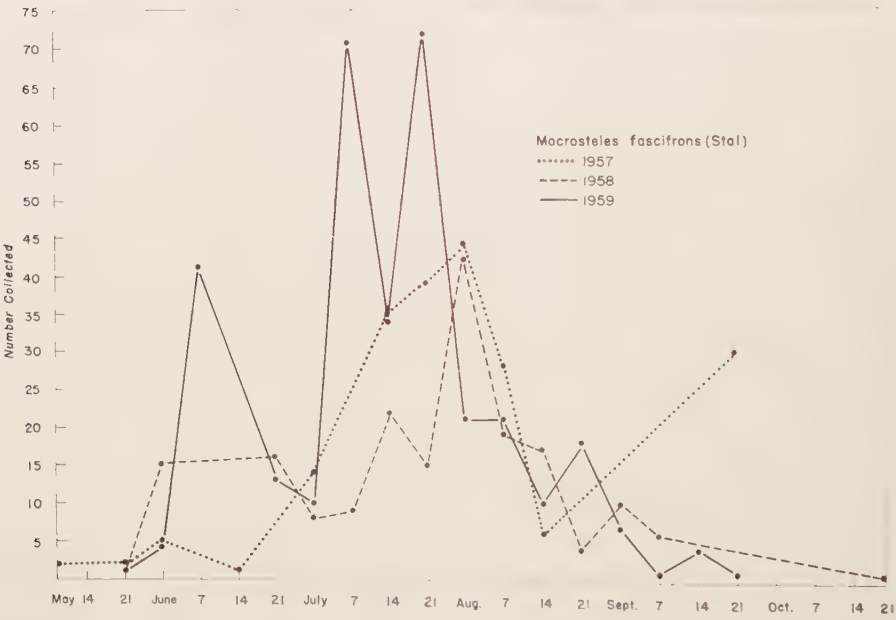

Fig. 2. Population distributon of *Macrosteles fascifrons* (Stal), six-spotted leafhopper, collected during 1957-1959.

Figure 3 represents the results of the collections of *Endria inimica* (Say). Unlike previous collections, *E. inimica* population levels remained fairly constant, without the definite high peaks observed in 1955 and 1956. This species is identified by Smith[20] as the vector for wheat streak mosaic virus which occurs in South Dakota. It has not, to this date, been accused of vectoring virus diseases in Michigan. If wheat streak mosaic virus should show up in Michigan, the popula-

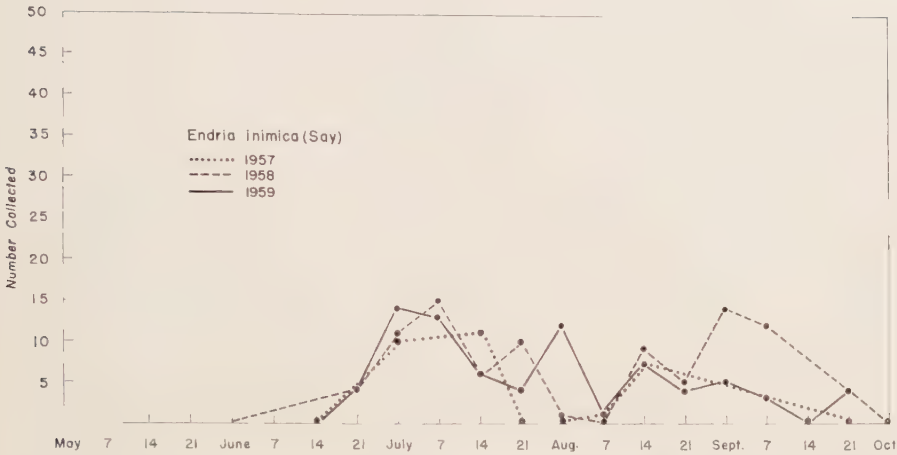

Fig. 3. Population distribution of *Endria inimica* (Say) collected during 1957-1959.

tion levels of this leafhopper would make it a serious problem in the grain producing areas of the state. *E. inimica* was collected from grasses and sour cherry.

Figure 4 demonstrates the populations of *Erythroneura* species of leafhoppers found in the collections. As with other species, prominent peaks in the population levels did not occur as they did in 1954 and 1956. Population levels from 1957 through 1959 were generally lower but were more consistently level. *Erythroneura* overwinters in forest debris and can be found at any time of the year. Those taken in these collections were active, flying leafhoppers. They are susceptible to DDT. Mosquito control projects, which employed aerial sprays of DDT in oil, were applied over wide areas during these collection years. Only one spray was applied each year by aeroplane

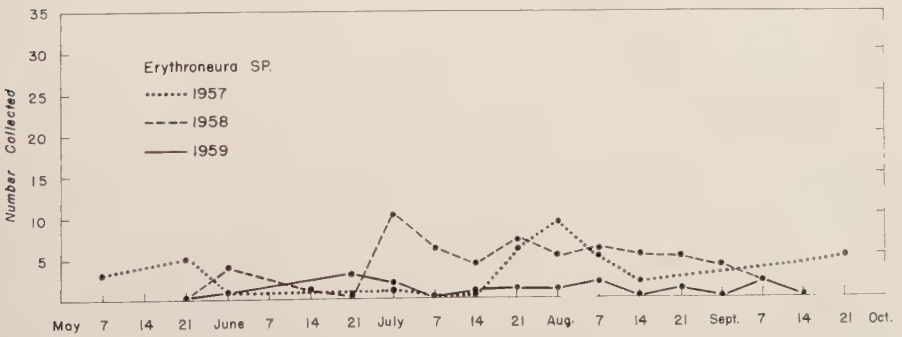

Fig. 4. Population distribution of *Erythroneura* sp. leafhoppers collected during 1957-1959.

and some of these sprays landed on collection sites. It is felt that these sprays have had their influence on the *Erythroneura* leafhopper populations. *Erythroneura* species were taken from grasses, *Prunus serotina, Crataegus* sp., *Rubus* sp., and sour cherry.

Figure 5 represents the results of all of the rest of the leafhoppers taken in these collections. *Empoasca* sp. females, for which no reliable keys exist, are included in this figure. No definite trends are discernible from these results. The following list includes the leafhoppers found in these collections and the hosts from which they were taken:

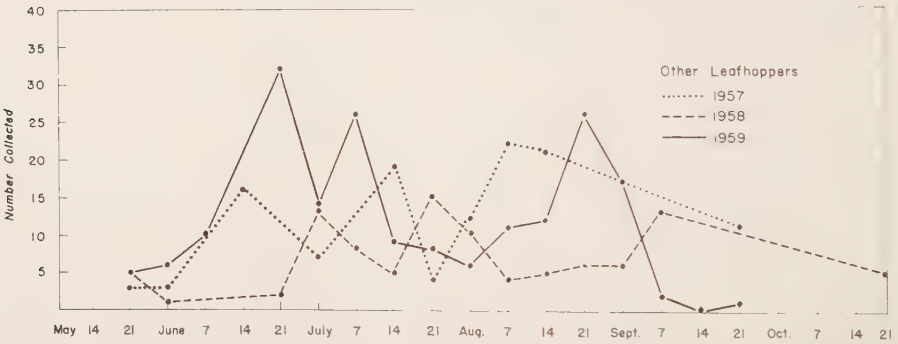

Fig. 5. Population distribution of all leafhoppers other than *Empoasca Fabae* (Harris), *Macrosteles Fascifrons* (Stal), *Endria Inimica* (Say), and *Erythroneura* sp. collected during 1957-1959.

LEAFHOPPER SURVEY 1957-59

Leafhopper	Disease vectored	Hosts from which taken
[a] *Aceratagallia sanguinolenta* (Prov.)	Potato yellow-dwarf virus	Grasses
[a] *Agallia constricta* V.D.	Clover wound tumor virus Potato yellow-dwarf virus	Grasses
[a] *Agallia quadripunctata* (Prov.)	Clover wound tumor virus Potato yellow-dwarf virus	*P. serotina*, grasses
Amblysellus curtisii (Fitch)		*P. serotina*
Balclutha impicta (V.D)		*P. serotina*
B. punctata (Thumb.)		*P. serotina*, grasses
Balclutha sp.		*P. serotina*, grasses, sour cherry
Cicadula sp.		*Rubus* sp.
[a] *Colladonus clitellarius* (Say)	X-disease of peach and cherry	*P. serotina*
C. eburatus V.D.[b]		Grasses

Leafhopper	Disease vectored	Hosts from which taken
Dikraneura sp.		*P. serotina*
Doratura stylata (Boh.)		Grasses
Draeculacephala antica (Walker)		*P. serotina,* grasses, *Rubus* sp.
D. constricta D. & DeL.		Grasses
D. mollipes (Say)		*P. serotina,* grasses
Draeculacephala sp.		*P. serotina,* grasses
Edwardsiana australis (Frogg.)		*P. serotina*
E. lethierryi (Ed.)		*P. serotina*
Empoa casta (McA.)		*P. serotina*
E. gillettei V.D.		Sour cherry
Empoa sp.		*P. serotina*
Empoa Gillettei Group		*P. serotina,* sour cherry
Empoasca sp.		*P. serotina, Rubus* sp., sour cherry
Erythroneura electa McA.		*P. serotina*
E. nitida Beamer		*P. serotina, Crataegus* sp., *Rubus* sp.
E. (probably *noevus* (Gillette))		Sour cherry
Erythroneura Obliqua Group		*P. serotina,* sour cherry
E. plena Beamer		*P. serotina*
E. tricincta (Fitch)		*P. serotina,* Crataegus sp., *Rubus* sp.
Erythroneura Vulnerata Group		*P. serotina*
Erythroneura sp.		*P. serotina,* grasses, *Rubus* sp.
Forcipata loca DeL. & Cald.		*P. serotina, Crataegus* sp., grasses
Graminella nigrifrons (Forbes)		Grasses
Graphocephala coccinia (Forster)		*P. serotina*
Gypona sp.		*P. serotina*
Gyponana extenda DeL.		*P. serotina*
G. tubera DeL.		*P. serotina*
Gyponinae sp.		*P. serotina*
Hebecephalus truncatus B. & T.		Grasses
Hebecephalus sp.		*Rubus* sp.
Helochara communis Fitch		Grasses
Macrosteles neglectus (DeL. & D.)		Grasses
Nesosteles sp.		Grasses
Norvellina seminuda (Say)		Sour cherry
Paraphlepsius irroratus (Say)		*P. serotina,* grasses, sour cherry
Psammotettex affinis (G. & B.)		Grasses
Psammotettex sp.		*P. serotina,* grasses, sour cherry
Scaphoideus major Osb.		*P. serotina*

Leafhopper	Disease vectored	Hosts from which taken
S. melanotus Osb.		*P. serotina*
[a]*Scaphytopius acutus* (Say)	Peach western X-disease virus Peach X-disease virus	*P. serotina*, grasses
S. frontalis (V.D.)		*P. serotina*, grasses
Scaphytopius sp.		*P. serotina*, *Crataegus* sp., grasses, *Rubus* sp., sour cherry
Typhlocyba cassiopeia Knull		*P. serotina*, grasses
Typhlocyba sp.		*P. serotina*

[a] Indicates known vectors for virus diseases known to occur in Michigan.
[b] Identified by James P. Kramer, U. S. Dept. of Agr., A.R.S., research division.

The following leafhoppers were not found in collections taken during 1954 through 1956:

Amblysellus curtisii (Fitch)
Collondonus eburatus V.D.
Edwardsiana lethierryi (Ed.)
Empoa casta (McA.)
E. gillettei V.D.
Erythroneura electa McA.
E. nitida Beamer
E. noevus (Gillette)
E. plena Beamer
Graphocephala coccinea (Forster)
Gyponana tubera DeL.
Hebecephalus truncatus B. & T.
Macrosteles neglectus (DeL. & D.)
Psammotettex affinis (G. & B.)
Scaphoideus major Osb.
S. melanotus Osb.
Scaphytopius acutus (Say)
Typhlocyba cassiopeia Knull

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BULLDOZING TO PRODUCE BROWSE FOR DEER[1]

By LESLIE W. GYSEL

Department of Fisheries and Wildlife

The main objective of this study was to determine the effects of bulldozing on plant species ordinarily used as browse by deer in different plant communities. Other major changes in the structure of these communities also are described. The use of various plant species and of different plant parts by deer is indicated: chemical analyses for some plants are given.

Forbes[2] reported that the forest types best suited to bulldozing for producing wildlife food and cover in Pennsylvania were, in order of desirability: beech-birch-maple, northern hardwoods transition, oak, and aspen. He concluded that compared to other methods, bulldozing produces a maximum amount of food and low ground cover available for use by wildlife and that bulldozed areas remain effective for a longer period of time.

In Michigan, Beale[3] found differences in sprouting success on different sites resulting from clear cutting with a tractor and tree cutter blade. Aspen sprouted prolificly; other trees and shrubs which formed numerous sprouts after cutting were cherry, willow, red maple, oak, dogwood, and *Viburnum spp.*

DECRIPTION OF THE AREA

The bulldozed areas analyzed in this study were in the Pine River Experimental Forest, 15 miles west of Cadillac in the Manistee National Forest. The topography is undulating to rolling and the soils are sandy. Major forest types are oak, aspen, and northern hardwoods.

[1]This study was made in cooperation with the East Lansing Research Center, Lake States Forest Expt. Sta.

[2]Forbes, S. E. and J. E. Harney, Jr. (1952). The bulldozer, a tool of wildlife management. Final Rpt. Pittman-Robertson Proj.; 31-R. Penn. Game Comm. 136 pp.

[3]Beale, D. (1960). Evaluation of mechanical tree cutting, Region II Mimeo. Rpt. No. 2271. Mich. Dept. Cons. Game Div.

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Bulldozed plots were in large oak and sugar maple stands and also in a small stand of red maple, in a willow stand on alluvial soil subject to flooding, and in an open area where staghorn sumac was the dominant tall shrub. According to field reports of the Game Division of the Michigan Conservation Department, there are approximately 20 to 30 deer per square mile.

METHOD

The bulldozing was done by a Caterpillar D-2 tractor with a standard dozer blade used for logging in the forest. The plots were bulldozed on June 21, 1956.

In a series of mil-acre plots, the following measurements were made after the bulldozing: percent of cover of all plant species to a height of 6 feet in the treated and untreated plots, and number of stems by diameter classes in untreated plots. In 1957 and in 1960, the greenweight of browse to a stem diameter of ⅛-inch and to a height of 6 feet was determined according to the following categories in the oak and maple stands: (1) crown branches, (2) epicormic branches, (3) seedlings or seedling sprouts, and (4) stump sprouts. Weighing of fresh plant parts was done in September. The amount of browsing by deer was noted, especially on plant parts of different origins. In 1956 and 1957, chemical analyses were made of crown stems and leaves, the terminal parts of epicormic branches, and stump sprouts which were within the reach of deer in one of the plots in the sugar maple stand.

RESULTS

Sugar Maple

Two plots, each 2 acres in area, were bulldozed in the sugar maple *(Acer saccharum)* stand. These plots were well stocked with approximately 3,000 stems per acre; two-thirds of these were saplings in the 1- and 2-inch d.b.h. classes, with some poles and scattered larger trees in the overstory. Eighty percent of the stems were sugar maple (Fig. 1).

Only a few tree branches were within reach of the deer before bulldozing; low ground cover consisted of a few clumps of grasses, sedges, maple-leaved viburnum *(Viburnum acerifolium)*, and a few seedlings. The weight of the browse in the untreated stands was 99 pounds per acre (Table 1), most of which was apparently unused.

Fig. 1. A part of the check plot adjacent to the bulldozed area in the sugar maple stand. Note the lack of browse and low cover. This is a poor wildlife habitat.

Bulldozing completely changed this stand structure. Approximately 50 percent of the tree cover was put on or near the ground (Fig. 2). Two months after the bulldozing, epicormic branches had developed along the horizontal tree boles and stump sprouts had formed at the base of the boles. During subsequent seasons, more epicormic branches and stump sprouts developed; some were kept low by browsing and others increased rapidly in height. The weight of the browse after five growing seasons was 12 times that in the adjacent check plots; most of it was sugar maple (Table 1). Approximately 85 percent of the stems and leaves within range of deer were from epicormic branches, stump sprouts, and seedlings.

It was soon apparent from numerous observations that browsing was heaviest on the stump and seedling sprouts (Fig. 3), intermediate on the epicormic branches, and lightest on the crown leaves and branches. In order to determine possible reasons for the variations in browse preference, a chemical analysis was made of stems and leaves from different parts of the trees. The amounts of ash, crude fiber, and nitrogen-free extract were greater and the amount of protein lower in the readily eaten browse than in the plant parts which were

TABLE 1—Green—weight of available browse according to origin, five growing seasons after bulldozing (pounds per acre)

Forest type	Species	Bulldozed plots					Check plots				
		Crown branches	Epicormic branches	Stump sprouts	Seedlings and seedling sprouts	Totals	Crown branches	Epicormic branches	Stump sprouts	Seedlings and seedling sprouts	Totals
Sugar Maple	Acer saccharum	201	526	147	46	920			9		9
	Fagus grandifolia						31				31
	Fraxinus americana				5	5					
	Quercus rubra			69		69					
	Prunus serotina				51	51					
	Ostrya virginiana			8	34	42				11	11
	Viburnum acerifolium				151	151				48	48
	Amelanchier spp.				5	5					
	Rubus allegheniensis				15	15					
	Aralia nudicaulis				2	2					
	Totals.....	201	526	224	309	1,260	31		9	59	99
Oak	Quercus alba	189	95	16	142	442	160			40	200
	Quercus ellipsoidalis				8	8					
	Quercus rubra				24	24				2	2
	Acer saccharinum			316		316	25			6	31
	Comptonia peregrina				76	76				126	126
	Totals.....	189	95	332	250	866	185			174	259

occasionally eaten (Table 2). It is possible that the amount of one of these components, or a combination of them, may affect odor, taste, or succulence.

Most plant species were browsed, some more completely than others. The few stump sprouts of white ash *(Fraxinus americana)* and serviceberry *(Amelanchier spp.)* were heavily browsed. The intensity of browsing was generally less on individual sprouts of sugar maple; however, the amount of sugar maple browse was much greater than that of the other species.

A large amount of browse and low cover will be available for at least 2 or 3 more years in the bulldozed plots. Approximately 50 percent of the bulldozed trees were still alive in September, 1960, and the epicormic branches and stump sprouts were still growing well. These covered 60 to 80 percent of the ground over much of the area. Herbs and shrubs were sparse.

Oak

This was a partially open stand composed mainly of small white oaks *(Quercus alba)* 1 to 4 inches d.b.h., 18 to 30 feet in height, with

Fig. 2. Crowns and stems of the bulldozed trees formed a dense ground cover in the sugar maple stand. Stump sprouts and epicormic branches developed on the horizontal stems a few weeks after the bulldozing.

Fig. 3. Note the numerous sprouts at the base of the main stem of the sapling sugar maple which had been broken during bulldozing. All of the sprout tips were browsed.

scattered larger trees to 9 inches d.b.h.; there were approximately 1,100 trees per acre. Sweet fern *(Comptonia peregrina)* and bracken fern *(Pteridium aquilinium)* were common in the understory. Lower branches of some of the small trees and a few seedlings were within

TABLE 2—Percent chemical composition of Sugar Maple browse(a)

Year of collection	Origin of browse	Ash	Crude fiber	Ether extract	Water	Protein	Nitrogen-free extract
1956	Crown stems and leaves	3.41	9.48	1.66	51.01	6.19	28.25
	Stump sprout stems and leaves	4.16	12.37	1.44	46.88	6.00	29.15
1957	Crown stems and leaves	2.57	8.98	1.83	56.86	5.18	24.58
	Epicormic branches and leaves	2.68	9.41	1.87	56.93	4.90	24.21
	Stump sprouts and leaves	3.19	10.14	2.18	54.76	4.68	25.05

(a) The analyses were made by personnel of the department of agricultural chemistry, Mich. State Univ. from fresh samples collected throughout the bulldozed area.

range of deer, but there was little evidence that these were used. Also, sweet fern was available, but apparently was little used. A 2½-acre plot was bulldozed in this type.

Approximately 60 percent of the crown cover was put at or near the ground by the bulldozing in June. By September, 70 percent of the tops of the trees which were down colored early. Later observations indicated that most of these trees gradually died. The remaining horizontal oak stems provided browse from crown branches, epicormic branches, and stump sprouts. Stump sprouts of red maple *(Acer rubrum)* were numerous around a few stumps. This type of browse, plus seedlings and seedling sprouts, weighed 866 pounds per acre (Table 1), over double that of the check area. The density of the grass cover also increased in the bulldozed area, but the density of the bracken fern and sweet fern decreased.

The amount of browsing varied from light to heavy during different years and was mainly on the stump sprouts of red maple and white oak. There was no evidence of browsing on plants available to deer in the check plot. Apparently the leaves and twigs of the lower branches of larger trees are unpalatable.

Red Maple

Within the ½-acre plot in this type, 27 clumps consisting of 178 stems were bulldozed. The diameter of the main stems ranged from 1 to 7 inches. All of the branches were above the reach of deer. The ground cover was mainly grass.

The crowns of the bulldozed trees provided low cover, although approximately one-half the crown areas were too high for deer to browse. At the end of the first growing season, only a few sprouts developed and no browsing was noted. By the end of the second growing season, however, epicormic branches and stump sprouts were numerous and heavily browsed. After five growing seasons, approximately one-half of the bulldozed trees were still alive and vigorous with crown leaves, epicormic branches, and stump sprouts.

Browsing was common on both the epicormic branches and stump sprouts by the end of the second growing season following the bulldozing. Some browsing also occurred on the crown branches. By the fifth growing season, however, heavy browsing occurred mainly on the stump sprouts.

Willow

The willows *(Salix bebbiana* and *S. patiolaris)* were in clumps of two to 10 stems, 1 to 5 inches d.b.h. and 12 to 20 feet in height; a few single stems of other species, such as quaking aspen *(Populus tremuloides)* and black cherry *(Prunus serotina)*, were also in the stand. There were 1,500 stems per acre; however, the crown cover was sparse while the cover of grasses, sedges, and herbs was dense. Very little browse was available. It was assumed that bulldozing might increase the aspen in the stand and might possibly provide a suitable habitat for the invasion of other woody species.

During the first three growing seasons following the bulldozing, grasses, sedges, and goldenrod *(Solidago spp.)* formed a dense cover with little else visible. During the last two growing seasons, numerous clumps of stump sprouts of willow grew above the grasses and a few aspen suckers also developed. The composition of the developing stand was similar to that of the check plot. Since the willows were only occasionally eaten by deer, the amount of palatable browse produced in this new stand was low.

Sumac

Staghorn sumac *(Rhus typhina)*, the tallest plant in this community, was 4 to 6 feet in height; it covered approximately 50 percent of the ground area. Grasses and sedges beneath the sumac formed a continuous cover. Blackberry *(Rubus allegheniensis)*, sweet fern, and bracken fern were also common. Most of the sumac stems appeared to be poor in vigor (Fig. 4); the leaf surface was small and the current growth was also small. Bulldozing was tried here to determine if the breaking of the old stems and the disturbance of the surface soil would stimulate sprout growth. Both sumac and blackberry were browsed by deer. The district ranger considered sumac to be one of the most valuable browse plants in the experimental forest area.

After two growing seasons following the bulldozing, blackberry, bracken fern, and grasses formed a dense cover. Five growing seasons after the bulldozing, vigorous stems of sumac were growing above this dense cover, approximately the same number of stems that were in the community before bulldozing. Both sumac and blackberry were browsed in the accessible parts of the area; however, many parts were inaccessible because of a dense tangle of blackberry stems.

Fig. 4. There were many dead branches and few leaves on the old sumac stems (photo taken June 20). Vigorous new sprouts, which are palatable deer browse, developed after the bulldozing.

OPERATION OF THE BULLDOZER

A small bulldozer, such as the one used on this project, limits the size of the trees that can be pushed down. In the stands which were bulldozed, however, there was no reason to remove all the trees. The oaks, which were most commonly left, produce acorns which are an excellent wildlife food.

In the willow and sumac areas, where there were no large trees, bulldozing time was 1 hour per acre. In the oak type and in one of the sugar maple plots, the time for bulldozing 2½ acres was 3 hours. In these areas, the bulldozer moved forward with few interruptions. In a second maple plot, where the trees were slightly taller and more dense and the topography rolling, the time for bulldozing 2 acres was 4 hours. Here, there were numerous delays due to the piling up of trees, requiring backing up of the bulldozer. The greatest difficulty

was incurred in the red maple type where bulldozing time for ½-acre was 1¼ hours. Often, three or more hits by the bulldozer were required to push over a clump; one clump of 13 stems required 15 minutes.

Cost for bulldozing on the plots, other than the last two described, was $22 per acre. This included the cost of the machine and the operator at the plot area.

SUMMARY

A tractor with a bulldozer blade was made to push down all or part of the woody vegetation in different plant communities to increase the amount of browse for deer.

In the sapling sugar maple stand, 1,260 pounds per acre of browse was available five growing seasons after the bulldozing; the check area had 99 pounds. Browsing was heaviest on stump and seedling sprouts, intermediate on epicormic branches, and lightest on crown branches. These preferences may result from differences in chemical content.

The amount of browse, after five growing seasons, in the oak type was 866 pounds per acre from a few oaks and red maples. Approximately two-thirds of the bulldozed trees died. Browsing occurred mainly on stump sprouts of red maple and white oak.

By the end of the second growing season after bulldozing in the red maple stand, numerous epicormic branches and stump sprouts had developed and were heavily browsed. One-half of the bulldozed tree boles were alive at the end of five growing seasons. Most of the browsing at this time occurred on the numerous stump sprouts.

The composition of the stand which was developing in the bulldozed willow plot was similar to that in the undisturbed check plot. Very little palatable browse was available.

In the bulldozed sumac plot, the composition of the plant community which was developing was similar to that in the check plot. Vigorous sumac sprouts and new growth of blackberry provided much browse.

Bulldozing is one method for producing large amounts of deer browse in some plant communities in the Pine River Experimental Forest area. This method could be used as a management procedure in sapling-pole sugar maple stands, and in areas in which staghorn sumac is a dominant plant species.

FITTING EXPONENTIAL FREQUENCY CURVES TO OBSERVED FREQUENCIES OF THE LENGTHS OF PRECIPITATION PERIODS AT SOUTH HAVEN AND MONROE, MICHIGAN

By W. D. BATEN[1] and A. H. EICHMEIER[2]

LENGTHS OF MEASURABLE precipitation periods at South Haven and Monroe, Michigan were obtained from records of the Weather Bureau Station at East Lansing, Michigan for the years from 1931 to 1959, inclusive. These two locations were chosen because the former is very near Lake Michigan while the latter is nearly due east of South Haven on Lake Erie. The object of this paper is to compare the distribution of lengths of precipitation periods for a place that receives the westerly winds from water areas and for a place that receives them from land areas.

The following table contains frequencies of the lengths of the precipitation periods from the above sites.

South Haven			*Monroe*		
Length of precipitation period - days mid point = x	Observed Freq. f_1	Expected Freq. f_2	Length of precipitation period - days mid point = x	Observed Freq. f	Expected Freq. f′
.5	992	977	.5	1003	1047
1.5	499	480	1.5	578	542
2.5	226	227	2.5	249	226
3.5	98	114	3.5	69	83
4.5	45	54	4.5	29	30
5.5	23	26	5.5	13	13
6.5	9	14	6.5	5	5
7.5	6	6	7.5	3	3
8.5	2	3			
9.5	1	1		1949	1949
10.5	1	1			
11.5	0	0			
12.5	1	0			
	1903	1903			

[1]Baten, W. D. Professor of statistics and agricultural experiment station statitician, Mich. State Univ.

[2]Eichmeier, A. H. State climatologist, U. S. Weather Bureau, East Lansing, Mich.

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On examining the observed frequencies, it is clear that the precipitation periods are longer at South Haven than at Monroe, but Monroe had more rains, snows, or both, than the location on the west side of the state; in fact, 10 per cent more. South Haven had more of these moisture periods that lasted 4 or more days than Monroe. At the former, there were periods of 9 days to 13 days. Figure 1 shows frequency histograms of these distributions.

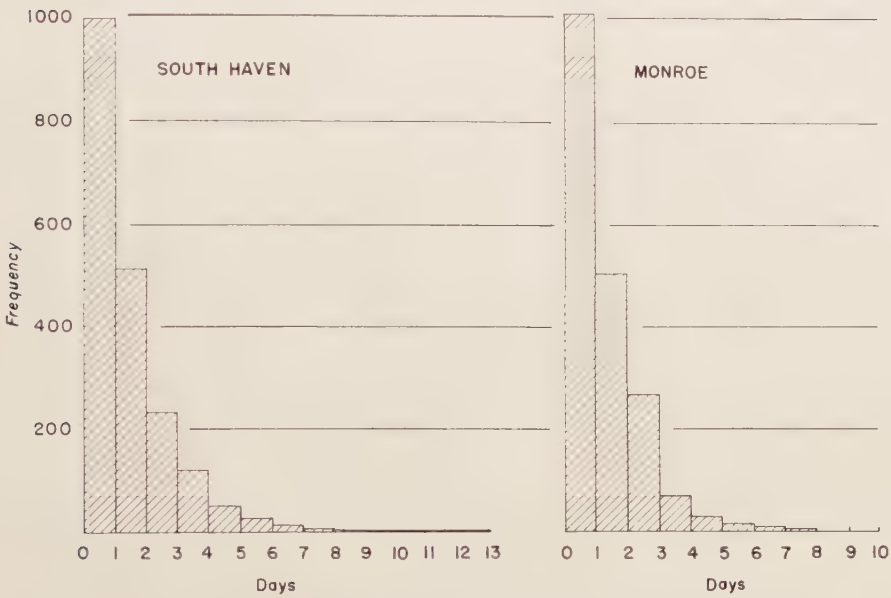

Fig. 1. Frequency Distributions of lengths of precipitation periods.

An exponential function with equation

$$(1) \quad f(x) = a\, e^{-bx} \text{ where } 0 \leqq x \leqq \infty ,$$

where e is the base of natural logarithms, were fitted to the above frequencies as follows. Since the area "under" a frequency curve is equal to 1 when the frequencies are expressed as decimals, then

$$(2) \quad \int_0^\infty f(x)\, dx = a \int_0^\infty e^{-bx}\, dx = 1$$

By equating the observed arithmetic average to the average of the fitted function the following was obtained.

(3)

$$\int_0^\infty x\, f(x)\, dx = a\int_0^\infty xe^{-bx}\, dx = \bar{x} \quad ,$$

where $\bar{x}$ is the observed arithmetic average.

From (2)

$$a\int_0^\infty e^{-bx}\, dx = a\left[-\frac{1}{b}\, e^{-bx}\right]_0^\infty = 1$$

or

$$\frac{a}{b} = 1 \qquad \text{or} \qquad a = b$$

From (3)

$$a\int_0^\infty xe^{-ax}\, dx = \bar{x}$$

$$= a\left[-x\,\frac{1}{a}\, e^{-ax}\right)_0^\infty + \frac{1}{a}\int_0^\infty e^{-ax}\, dx\Bigg] = \bar{x}$$

or

$$1/a = \bar{x} \qquad \text{and} \qquad a = 1/\bar{x}$$

The frequency function to be fitted to the observed at South Haven is

$$N\, f(x) = (1903)\,(.723)e^{-.723x} \quad ,$$

where N is the total of the frequencies.

The area under the fitted curve between i and i + 1, where i takes integral values and also zero, is

$$N\int_i^{i+1} f(x)\, dx = N(e^{ix} - e^{(i+1)x}) \quad .$$

The expected frequency in the third class; that is, from 2 to 3, for South Haven is

$$1903\ \left[e^{-1.446} - e^{-2.169}\right] = 1903\ \left[.23457 - .11533\right] = 227$$

The other expected frequencies were similarly found.

A Chi-square test was used to determine whether or not expected frequencies fit the observed frequencies. This test indicated that

there is no evidence that the expected frequencies do not fit the observed values.

A similar exponential function was fitted to the Monroe data and found not to fit the observed frequencies. This indicates that the frequencies for the western site follow an exponential function of the form $N\,ae^{-ax}$ and those of the eastern site do not; showing that the distribution of the lengths of precipitations are not similar.

An equation of the form

$$\hat{y} = 10^{a+bx+cx^2+dx^3},$$

or

$$\log \hat{y} = a+bx+cx^2+dx^3$$

was fitted by the method of least squares to the Monroe data and was found to be

$$\log \hat{y} = 3.11422 - .15083x - .07881x^2 + .00695x^3.$$

A Chi-square test showed that the fit was good for the frequencies center at the mid points of the classes.

The expected frequencies are given in the above table.

This article has shown that the frequencies of the precipitation periods at South Haven are different from those at Monroe because the fitted functions are different.

"RED LACED SILVER," A NEW COLOR PATTERN OF CHICKENS

By EARL W. HENDERSON

POULTRY SCIENCE DEPARTMENT

A NEW COLOR STRAIN of chickens, which has many practical advantages, was developed and described for the first time at the Michigan Agricultural Experiment Station in 1953.[1,2]

The Red Laced Silver phenotype was unique in the U. S. in 1953 and to date has not been reported in other states. The gene complex responsible is under investigation. Many different genes are involved. The white portion of the pattern has been identified as "Silver,"[3] a gene which is sex-linked. Male "Silver" chicks are lighter colored than their sisters, when they have been sired by red males and mothered by "Silver" hens. "Silver" (white) colored varieties are preferred in most U. S. markets over dark varieties because they have more white. Light colored chickens have fewer dark pin feathers when plucked.

Since the discovery of the Red Laced Silver color pattern, attempts have been made to add other good characteristics to the strain. These include fast growth, high hatching power, good meat type, and good laying ability.

Breeding activity has been centered recently on the genetic puzzle of the color pattern. The relative infrequency of the Red Laced Silver color among progenies from matings, which might logically be expected to produce it, has indicated that genetically it is very complex. The purpose of the present report is to record additional information of the color patterns obtained among progenies of pedigreed matings of specific phenotypes.

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[1]Henderson, Earl W. (1953). A new Red Laced Silver mutant chicken. Mich. Agr. Expt. Sta. Quart. Bul. 36: 198-201.

[2]_____ (1954). The genetics of a Red Laced White mutant chicken. Proc. Tenth World's Poultry Congress. Part 2: 5-9. Dept. of Agr. for Scotland, St. Andrews House, Edinburgh.

[3]_____ (1959). Sex identification by down color of Silver Laced and "Red Laced Silver" chicks. Poul. Sci. 37: 599-602.

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Materials

The materials available consisted of individual males on which the Red Laced Silver plumage pattern was definitely evident, the sisters of these males, some unrelated males and some "red" colored females.

Poultry breeders are well aware that the descriptive term of "red", as applied to plumage color of chickens, normally includes flecks of black and/or tan along with variable intensities of red in or on various plumage areas of fowls. In general, both colors and plumage descriptive terms in poultry are actually relative in meaning. Nevertheless, color and pattern categories are sufficiently specific and acceptable to most everyone familiar with fowls. Whether the deviations from "standard" definitions of categories have genetic significance is a problem of research in the field of inheritance.

The ancestry of the "Red Laced Silver" strain included a Cornish variety which is well known for its broad, thick meated breast. Some of the meat qualities of the "Red Laced Silvers" were utilized in crosses which produced Michigan Miniature Broilers in 1956.[4]

Experimental Procedure

The breeding procedures, which produced the phenotypes described in this report, would be classified mainly as "back crosses." The original mating producing the Red Laced Silver phenotype was a Silver Laced (B.L.W.) male X a red female.[1,2] More recent cross matings are listed in Table 1.

Good production characters were considered in the selection of parental stock. Progenies were tested and classified for both color and production characteristics.

Management, housing, nutrition and brooding were routine by prevailing standards. Management practices were uniform within the population. Therefore, any color differences might reasonably be attributed to ancestry.

Results

The distribution of color phenotypes is shown in Table 1. Color phenotypes are not the same as those defined in orthodox "standard" categories, but rather the nearest resemblance to some established color pattern.

[4]Henderson, Earl W., L. E. Dawson, H. C. Zindel, and E. H. Farmer (1956). "Michigan Miniature" broiler production. Mich. Agr. Expt. Sta. Quart. Bul. 38: 547-554.

It will be clear to those familiar with "Standard" color patterns of poultry and genetic theory that there are a number of unexpected phenotypes in Table 1. Some of the most striking examples are (1) red and/or "Dark Cornish" males in columns No. 3 and 7. If the sires used with the red, white and cream colored dams were pure red, i.e., (Gold), and if the dams were pure "Silvers", all the red and/or Dark (Gold) progeny should have been females.

TABLE 1—Distribution of color phenotypes(a) of progenies—Types of matings

		Color of sires—Red Laced White						Color of sires—red
		Color of dams						Color of dams
Column No.		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Color, sex and number of progeny		Red and/or buff	R.L.W.	R & W cream	Col.	White (Ss)	White (ss)	R & W cream
Color	Sex							
Red or buff	M	11	—	6	—	—	2	5
	F	21	7	8	6	6	1	46
D.C.	M	5	2	2	—	—	3	3
	F	5	2	3	—	—	—	5
R.L.W.	M	1	1	8	—	—	—	7
	F	—	—	2	—	—	—	—
R & W	M	3	—	10	1	1	—	11
	F	7	1	7	—	—	—	3
Col. red dots	M	5	—	2	1	1	—	13
	F	5	3	3	—	—	—	—
Col. blk. dots	M	9	10	2	5	5	—	9
	F	3	1	—	—	2	—	—
B.L.W.	M	2	3	1	3	—	—	3
	F	—	1	1	—	1	—	—
Sil. pen.	M	1	—	—	—	—	—	—
	F	—	1	—	—	1	1	—
Sil. grey	M	—	—	—	—	—	—	—
	F	—	1	—	—	1	—	—
Blk. & wht.	M	1	—	—	—	—	—	—
	F	—	—	—	—	—	—	—

TABLE 1—Continued

		Color of sires—Red Laced White						Color of sires—red
		Color of dams						Color of dams
Column No.		(1)	(2)	(3)	(4)	(5)	(6)	(7)
Color, sex and number of progeny		Red and/or buff	R.L.W.	R & W cream	Col.	White (Ss)	White (ss)	R & W cream
Color	Sex							
Mix. sil. B&W+bar	M	—	—	—	—	4	—	3
	F	2	1	—	—	—	—	—
Red & W. bars	M	—	—	—	—	1	—	—
	F	1	—	—	—	—	—	—
Blk. & grey	M	—	—	—	—	—	—	2
	F	—	—	—	—	—	—	—
Wht. L. blk.	M	1		—	—	—	—	—
	F	—	—	—	—	—	—	—
White	M	—	1	—	—	—	—	—
	F	—	—	—	—	—	—	—
TOTALS.....		83	35	55	16	23	7	110

(*a*) Color phenotypes are abbreviated in the table according to a code system (See Legend).

LEGEND OF ABBREVIATIONS IN TABLE 1

R.L.W. = Red Laced White (See Fig. 1)
R & W/cream = Red and White on back, creamy white breast and body (See Fig. 2)
Col. = Columbian
D.C. = Dark Cornish
R & W = Red and White (no distinct pattern)
B.L.W. = Black Laced White (Silver Laced)
Sil. pen. = Silver Pencilled
Sil. grey = Silver Grey
Blk. & wht. = Black and White (no distinct pattern)
Mix. sil. B & W bars = Mixed Silver, black and white, plus black and white bars
Red & W. bars = Red and White Bars (a la Oklabars)
Blk. & grey = Black and grey, usually including very indistinct barring and some splashes of red
Wht. L. blk. = White laced black (reverse of B.L.W.)

As it has been pointed out a number of times in reports from this project, the phenotypes encountered are not orthodox. Some of the sires could have carried "Silver" in the form of imperceptible grey spots in their plumage. There could have been errors in sex determinations. Sexes were classified at 10 weeks of age. An error of judgment in eight out of 110 cases (column 7) may be normal. Only three of the 51 "Silver' phenotypes were classed as females in column No. 7. All classifications of progenies were made at random, usually on the growing range, without reference to the colors of their ancestry.

Attention should be directed to at least two phenotypic classifications. The Red Laced White (which has proven to be Silver) is probably heterozygous in both sexes. "R.L.W." is differentiated from R & W/crm. (red and white, and cream), but full sisters of Red Laced White males may carry either color pattern. The two "Columbian" classifications and the Red Whites are perhaps differentiated unnecessarily. The distinctions among them must be entirely arbitrary.

Most of the "whites" are "Silvers" (Ss), but at least one "white" has proven to be recessive to color, i.e., (cc) and or (ss). The "Silver" whites are presumably "Columbians", which lack the usual flecks of black distinguishing this orthodox phenotype.

No distinction was attempted between the two types of Dark Cornish, i.e., Black Laced Reds and "Partridge." The distinction between these two phenotypes is sometimes difficult with mature fowl and much more so with chickens at 10 weeks of age.

The general type of matings in the several columns would probably be classified as follows: Column (1) back-cross, (2) F_2, (3) F_2, (4) out-cross, (5) out-cross, and (6) out-cross. Column (7) is obviously the reciprocal back-cross to column (1).

Is Red Laced White-Multiple Dominant?

The genotype of the "Red Laced White" phenotype is still a genetic puzzle. It seems to be the result of a combination of many genes, some of which are dominant. The scarcity of females with the definite red lacing on a creamy white breast suggests that more than two genes for lacing must be present, one of which may be sex-linked. It is difficult to explain the scarcity of laced phenotypes from the mating of column 2. (Both sire and dam were distinctly laced.)

If it may be assumed that both sires and dams were heterozygous dominants, there should have been about 27 laced progenies out of

a total of 35, half of which should have been females. On the contrary, however, there was only *one* Red Laced White male and *no* Red Laced White females among the progenies. There were three *Black* Laced White males and one *Black* Laced White female. Black is presumably dominant to Red, but there were no Black Laced White phenotypes among the parents of the progenies in column (2). There may have been a few Black Laced Red females among the dams in mating No. 1, but this mating produced only two Black Laced White progeny out of a total of 83.

There are many other unsolved color pattern puzzles from matings in this project. For instance, the color pattern of hens which would seem most logical from the mating of column (2) is "Red Laced Silver," illustrated in Fig. 1. Red Laced Silver is rarely obtained on females from this mating. The color pattern of females most commonly obtained for the mating of column (2) is the (R & W/crm.) illustrated in Fig. 2.

The Red Laced Silver X R & W crm. mating (column (3)) produces a far greater (15% vs. 3%) proportion of Red Laced Silver progeny than the mating of column (2).

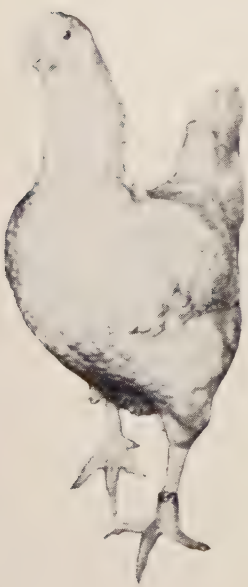

Figure 1

Figure 2

Fig. 1 is an illustration of one of the few "red laced silver" females obtained from a red laced silver sire. R & W/crm (Fig. 2) is more common from this cross.

Experiments have shown that the white portion of the "Red Laced Silver" color complex is what the geneticist calls sex-linked. It can be used in hatchery matings to permit the identification by their color of the sex of baby chicks at hatching time.

The under color of most of the stock from the variety is creamy white, which means fewer dark pin feathers on dressed carcasses. The strain would qualify as a "heavy" type and should bring a premium above egg laying strains as market fowl.

The wide diversity of color patterns from orthodox genetic phenotypes in Table 1 serves to establish at least two situations: (1) the number of progeny necessary to insure the appearance of all possible color pattern combinations is far greater than might be expected, (2) some genetic theories need re-examination or revision.

Further attempts to explain the apparent discrepancies from established genetic theory will not be tried. The data are submitted for whatever assistance they may be to those interested in establishing new genotypes of poultry.

One of the present day "draw-backs" of the Red Laced Silver strain is the number of highly unpredictable color patterns which occur among the progeny. In this respect, it is far from a variety which can be released as "perfected." With its many good utility qualities, it should make an excellent all purpose chicken after a few generations of selection.

PRACTICAL HYDROLOGIC CONCEPTS CONCERNING A SMALL, MICHIGAN, AGRICULTURAL WATERSHED[1]

By EARL A. MYERS and E. H. KIDDER[2]

PEAK RUNOFF RATES from small-area storms are critical in the design of spillways for dams, drainage systems, flood protection works, culverts, bridges, and storm sewers. Runoff volumes from these areas are also necessary in the design of irrigation systems, flood storage reservoirs, and other water detention and storage structures. Little detailed hydrologic data is available from agricultural watersheds of 5 to 25 square miles in size.

It is for the above reasons that in 1954, the Michigan Water Resources Commission; Surface Water Branch, Michigan District Office, United States Geological Survey; United States Weather Bureau Office at East Lansing; and the Agricultural Engineering Department, Michigan State University, East Lansing, cooperatively initiated a research project.[3] One of the watersheds selected for study was the Sloan Creek area near Williamston in south-central Michigan, from which the data for this paper have been secured (Figures 1-3).

The dominant land use of the Sloan Creek watershed was agricultural, with no urban infringement. Nearly 60 percent of the area was cropland, with corn being the major crop. About 12 percent of the area was in pasture and 20 percent either idle or in woodland.

The drainage area above the stream gage was 9.34 square miles. The topography was flat to gently rolling and the channel slopes averaged 10 feet per mile. The main channel, a constructed drainage

[1]This article is based on the Ph.D. thesis by Earl A. Myers entitled, "Hydrologic analysis of a small agricultural watershed". The authors gratefully acknowledge the cooperation of A. D. Ash, A. H. Eichmeier, and R. Z. Wheaton for supplying background information for this paper.

[2]Formerly graduate assistant (now assistant professor, Pennsylvania State University) and associate professor, respectively, department of agricultural engineering.

[3]Ash, A. D., A. H. Eichmeier, E. H. Kidder, D. W. Granger et. al. (1958). Hydrologic studies of small watersheds in agricultural areas of southern Michigan, Report No. 1. Water Resources Commission, Lansing, Mich. 77 pp.

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ditch excavated about 1917, had several small meanderings; however, the ditch bottom was generally straight and reasonably clear of debris and woody vegetative growth.

The watershed had mainly imperfectly-drained Conover and poorly-drained Brookston loam to clay loam soils with less than 5 percent of the area occupied by undulating to rolling, well-drained, sandy loam Hillsdale and Bellefontaine soils.

In June, 1954 the United States Geological Survey established the stream gaging station and since then has been completely responsible for its operation and maintenance. Recording raingage stations were established in April 1956 by the Weather Bureau. Locations of the raingages, including the area each represents and the stream gage, are also shown in Fig. 3.

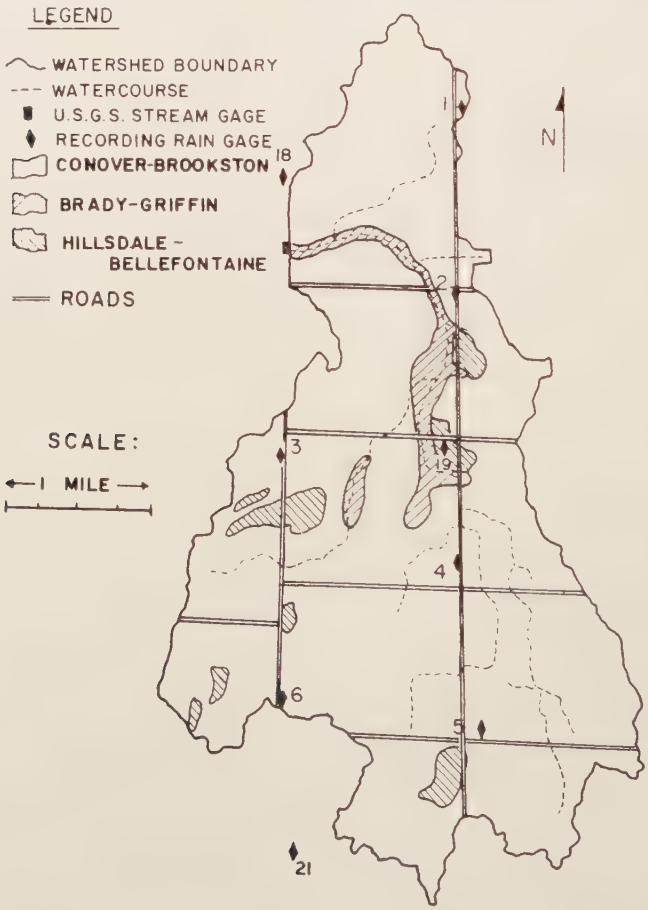

Fig. 1. Sloan Creek basin.

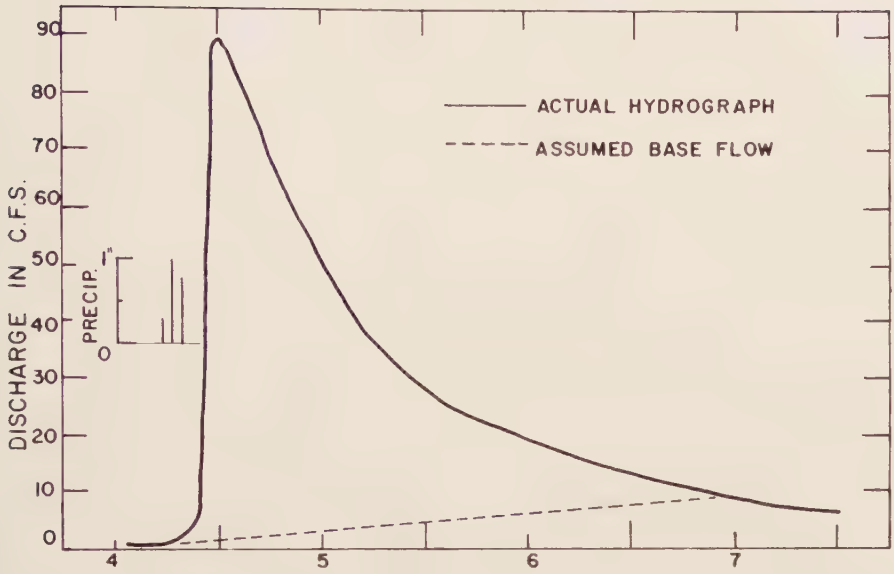

Fig. 2. Sloan Creek hydrograph, July 4-7, 1957.

The storms considered in this analysis are essentially of two types: 1. the steady, rather uniform, and widespread rains occurring during the approach of warm fronts with stable air masses, and 2. the thunder-shower type, which develops in connection with convectively unstable air masses or the passage of cold fronts and squall lines. Existing Weather Bureau raingage stations spaced 20 to 30 miles apart serve well for describing storms of the first category; however, the irregularly distributed and small-area summertime storms may pass between these stations.

A comparison was made between weighted averages, which considered the area each gage represented, and unweighted averages of rainfall for 18 storm periods. This comparison showed that 50 percent of these averages differed by less than 1 percent and that none differed more than by 0.08 inch. Thus, for most small agricultural work, averaging methods more detailed than unweighted averages are unnecessary with this type of topography and gage spacing.

Great variation, however, was noted when single gages at opposite ends of the watershed were compared. The May 15, 1957 storm produced rainfall amounts ranging from 1.36 inches at gage 1 to 0.26 inch at gage 6. The range for the August 16, 1959 storm

was 1.64 inches at gage 2 to 0.23 inch at gage 5. The distances between gage 1 and 6 and 2 and 5 were, respectively, 4.3 and 3.0 miles. These data indicate that for accurate rainfall information, it is imperative that irrigation farmers have their own raingages.

Table 1 shows the data used in analyzing the 15 most appropriate storms which occurred on the watershed during the nearly 5 years of records. The average total inches of rainfall over the watershed, as determined by the recording raingages, is listed for each storm period in column 2.

The amounts of runoff shown in column 3 were determined from runoff hydrographs of the watershed, hydrograph being defined as a graph of discharge rate versus time. Figure 2 is a typical hydrograph

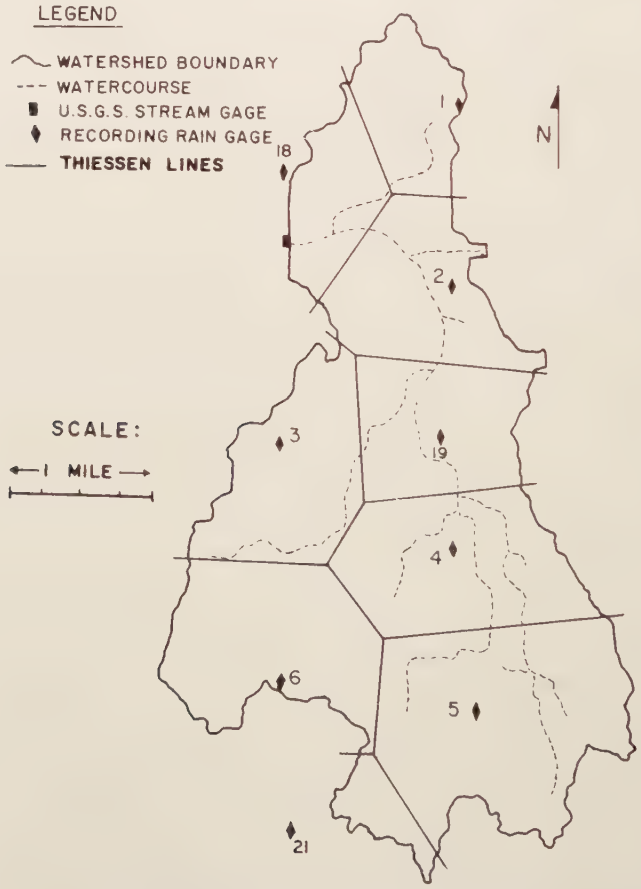

Fig. 3. Sloan Creek basin nine cage Thiessen procedure.

TABLE 1—Data used in the analysis of the rainfall-runoff process for the watershed

(1) Date	(2) Rainfall, Inches	(3) Runoff, Inches	(4) 2-3 Inches	(5)(*a*) Ant. moist., Inches	(6) Total moist., Inches	(7)(*b*) Infl., Inches	(8) Prior to runoff, Inches
Aug. 9-12, 1956.....	2.15	0.22	0.93	0.47	2.40	0.19	2.21
Aug. 17-20, 1956.....	1.19	0.09	1.10	0.00	1.10	0.19	0.91*
Apr. 27-30, 1957.....	0.67	0.24	0.43	0.88	1.31	0.25	1.06
May 14-17, 1957.....	0.60	0.14	0.46	0.59	1.05	0.09	0.96
May 18-21, 1957.....	1.80	0.85	0.95	0.65	1.60	0.65	0.95
July 4- 7, 1957.....	2.09	0.29	1.80	0.00	1.80	0.25	1.55
July 8-11, 1957.....	1.19	0.22	0.97	0.55	1.52	0.44	1.08(*c*)
July 11-14, 1957.....	3.69	1.70	1.99	0.50	2.49	1.13	1.36(*c*)
Nov. 14-17, 1957.....	1.13	0.11	1.02	0.40	1.42	0.59	0.83
Apr. 6- 9, 1958.....	0.82	0.10	0.72	0.35	1.07	0.28	0.79
July 28-31, 1958.....	1.20	0.01	1.19	0.00	1.19	0.19	1.00(*c*)
May 23-26, 1959.....	1.07	0.05	1.02	0.38	1.40	0.34	1.06
Aug. 16-19, 1959.....	0.84	0.14	0.70	0.88	1.58	0.19	1.39
Sept. 21-24, 1959.....	1.74	0.08	1.66	0.00	1.66	0.56	1.10
Oct. 6- 9, 1959.....	3.28	1.41	1.87	0.54	2.41	1.20	1.21

(*a*) Antecedent moisture.
(*b*) Infiltration.
(*c*) Storms not appropriate to comparison with others.

of the watershed and includes average hourly precipitation amounts as well as actual total and assumed base discharge rates.

The actual hydrograph (solid line) is a measure of total surficial outflow and includes certain amounts of base flow which were derived from groundwater. The straight, dashed, base flow line essentially separates that portion due to surface runoff from that due to groundwater. Surface runoff, that portion between the hydrograph and base flow lines, was determined by planimetering the area and converting this into average depth over the total watershed.

Column 4 is merely the difference between the amount of rain which fell and the amount which ran off. This amount of water from the storm having just occurred did not leave the watershed as surface flow and had to be accounted for in some other way.

Ten days of antecedent precipitation were considered to affect runoff for April, May, and November and only 5 days for July, August, September, and early October. The specific fraction of the rain which was considered effective for each of these preceding days were 0.9, 0.7, 0.5, 0.4, 0.3, 0.2, 0.2, 0.1, 0.1, and 0.1 for the 10-day period and

0.9, 0.7, 0.5, 0.3, and 0.1 for the 5-day period. These depletion rates compare favorably with irrigation concepts, as well as with prior hydrologic analyses.

The specific values of effective antecedent moisture, computed for the surface 8 to 12 inches of soil of the watershed prior to each storm period, are listed in column 5. These values, added to the moisture of column 4, gave the total inches of moisture in the basin which had to be accounted for at the end of the storm period. They are listed in column 6.

Rainfall which did not run off as surface flow during the storm period was considered a combination of infiltration, surface storage, and detention storage. The surface and detention storage of a watershed is reasonably uniform from storm to storm, but infiltration is extremely variable. Infiltration depends not only upon the physical characteristics of the soil and the cover on the soil, but also on such factors as soil moisture, temperature, and rainfall intensity. Since the initial infiltration rate is much more rapid and more variable than the "normally approached constant infiltration rate", both were considered separately.

The "constant" infiltration rate was estimated at 1 32-inch per hour for April, May, and November and 1 16-inch per hour for July, August, September and October. The values for each of the two periods were determined from hydrographs which occurred due to low intensity but long duration storms.

Each infiltration amount of column 7 was obtained by multiplying the appropriate infiltration rate by the effective time the water was on the surface. This moisture was assumed to have gone into the deeper soil strata of the watershed and to be no longer effective watershed moisture.

The total effective moisture required prior to surface runoff for each storm is listed in column 8 and was determined by subtracting column 7 from column 6. Total effective moisture included surface storage, detention storage, initial infiltration, and effective antecedent moisture.

Column 8 indicates the total effective moisture required to produce runoff from month to month throughout the season. Omitting those with (c) after them, the values increased from spring through the middle of August and then decreased from there to winter.

The storm periods marked with (c) are not appropriate for comparison. The storm of July 28-31, 1958 produced virtually no runoff,

while the other three followed previous storms which had substantially increased the substrata moisture in the watershed.

The unit graph method, as discussed by Linsley, Kohler, and Paulhus[4], of estimating peaks and amounts of flood discharge was considered in the study. The ½-hour unit graphs of August 17-20, 1956 and May 14-17, 1957 were combined and the composite was then converted into a 1-hour unit graph. This 1-hour composite unit graph was combined with the August 9-12, 1956 1-hour unit graph to give the most appropriate unit graph for the watershed. The composite 1-hour unit graph was used to determine expected hydrographs for four actual storms. The calculated and actual peaks differed by the following amounts, based on the actual peak values: July 4-7, 1957, plus 55 percent; July 8-11, 1957, plus 56 percent; July 11-14, 1957, minus 19 percent; and October 6-9, 1959, minus 16 percent.

Thus the unit graph method of analysis was considered very satisfactory for estimating peak flows and volumes of discharge for watersheds where at least several years of records exist. It must be remembered that in this study, however, the percent of runoff was already known and was used in determining the peak flows. In practice, this also would have to be estimated and thus even greater deviation between calculated and actual peaks should be expected.

To illustrate the rational formula approach, as described in Low Dams[5], the design peak runoff rate was determined for a once-in-25-years frequency storm. A time of concentration of 6 hours was determined, which gave approximately 0.5 inch per hour for the rainfall intensity. Considering a runoff coefficient of 0.5 for the relatively flat and undulating watershed of 5,980 acres gave a 1495 c.f.s. peak flow. The highest peak thus far recorded was 644 c.f.s. for the July 11-14, 1957 period; however, this value would have been much higher if the rain had occurred at a continuous and uniform rate.

The results obtained indicate that if properly used, the rational formula can predict with reasonable accuracy design peak runoff rates for storms of particular frequencies. Its greatest value is for estimating peak runoff rates for the smaller watersheds where no rainfall or runoff records exist.

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[4]Linsley, Ray K., Max A. Kohler and J. H. Paulhus (1958). *Hydrology For Engineers.* McGraw-Hill Book Company, Inc., New York. 340 pp.

[5]Small Water Storage Projects sub-committee of National Resources Committee (1938). *Low Dams.* U. S. Government Printing Office, Washington, D. C. 131 pp.

CONCLUSIONS

1. For much small-area work, rainfall averaging methods more detailed than unweighted averages are unnecessary.

2. Accurate rainfall information, as needed by irrigation farmers, necessitates a minimum of one raingage per square mile.

3. Initial infiltration varies extensively throughout the season, generally increasing from spring through late summer and then slowly decreasing towards winter.

4. For watersheds up to nearly 10 square miles, the rational formula may be advantageously used for estimating peak design rates of runoff if no prior records exist.

5. The unit graph method is preferred:

   a. where rainfall or runoff records exist or can be closely approximated.

   b. where both peak flows and total volumes are desired.

   c. where large areas and high hazard structures are involved.

PINE AND SPRUCE PLANTINGS ON THE LOWITZ FARM IN CASS COUNTY, MICHIGAN

By VICTOR J. RUDOLPH[1] and STUART W. McCULLOUGH[2]

SEVERAL DECISIONS which must be made in the establishment of a forest plantation are:

1. What species should be planted?
2. Should the planting be of one species, or a mixture of several species in various mixing arrangements?
3. What spacing should be used?

Available information on these items for some species currently being planted in Michigan is frequently inadequate. Additional information which can be obtained from existing plantations of various species, mixtures, and spacing, however meager, will be helpful in planning forest plantations for Michigan.

A 25-year-old plantation on the Lowitz Farm in Cass County, Michigan provides an opportunity to evaluate six species in pure and mixed arrangements at wider than usual spacings. The plantings include 5 pine species—Scotch pine (*Pinus sylvestris* L.)[3], white pine (*P. strobus* L.), red pine (*P. resinosa* Ait.), Austrian pine (*P. nigra* Arnold), ponderosa pine (*P. ponderosa* Laws)—and one mixture of white pine and Norway spruce (*Picea abies* (L.) Karst.).

The plantings occupy 40 acres on the Lowitz Farm approximately two miles southwest of Cassopolis.

Alternate rows throughout the entire area were planted to chestnut (*Castenea dentata* (Marsh.) Borkh.). Within several years after planting, most of the chestnut succumbed to the chestnut blight, caused by the fungus (*Endothia parasitica* (Murr.) A. & A.). Subse-

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[2]Formerly Resident Forester, Fred Russ Forest.
[3]Scientific names are according to Little, E. L. Jr. (1953). *Check List of Native and Naturalized Trees in the United States.* U. S. Department of Agriculture, Handbook 41.

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quently, the few remaining diseased stems were removed. The loss of the chestnut resulted in rather wide spacings, averaging 17 feet, between the rows of the pines and spruce. Thus, the plantings are unique in the wide spacings under which they have grown.

Growth of these plantings indicates the suitability of these species for planting on similar areas, in pure and mixed arrangements. The plantings also show the early effects of the unusually wide spacings upon individual tree growth, and on growth in volume per acre.

The plantation area is gently rolling, with good surface drainage except for one small, shallow pond. The soils range from sandy loams to loamy sands, and are predominantly of the Kalamazoo and Oshtemo series.[4] Internal drainage of these soils is good. These soils are common in southern Michigan, and often are available for tree planting after being abandoned for cultivated crop use.

The area was plowed and disked prior to hand-planting in the spring of 1935. The planting stock was 2-0 seedlings obtained from a nursery in New Hampshire. There was no cultivation of the trees after planting.

Species Arrangement and Spacing

Originally, the rows in the plantings were spaced approximately 8 feet apart. After loss of the chestnut, the present arrangement of the species and mixtures in a north-south strip-wise pattern from east to west on the 40-acre area, with average residual spacing, is as follows:

1. Scotch pine, 11 rows, spaced approximately 17 x 15 feet; 5.6 acres.
2. White pine, 13 rows, spaced approximately 17 x 15 feet; 6.7 acres.
3. Red pine, nine rows, spaced approximately 17 x 8 feet; 4.6 acres.
4. Ponderosa pine, nine rows, spaced approximately 17 x 8 feet; 4.6 acres.
5. White pine-ponderosa pine, in six alternate rows, spaced approximately 17 x 10 feet; 2.5 acres.
6. White pine-Austrian pine, in 20 alternate rows, spaced approximately 17 x 10 feet; 10.3 acres.
7. White pine-ponderosa pine, in nine alternate rows, spaced approximately 17 x 15 feet; 4.6 acres.

[4]The soils were dentified by W. Westrate, Soil Conservation Service, Kalamazoo, Michigan.

8. White pine-Norway spruce, in six alternate rows, spaced approximately 15 x 15 feet; 2.5 acres.

Field Procedure

The plantation was mapped to determine the species distribution, and adequate sample plots were taken in each portion of the plantings for data on a per-acre basis for the 25-year-old stands. Pulpwood volume in cords assumes utilization of each tree to a minimum 4-inch inside bark top diameter.[5] Paired sample trees of the species, growing in mixture, were measured for statistical evaluation of species differences in diameter and height growth.

Data for the 25-Year-Old Stands

Tables 1 through 7 present the data for the various portions of the plantation, and Table 8 summarizes data for all plantings.

TABLE 1—Scotch pine stand, 1960

Diameter breast height(*a*)	Trees per acre	Average total height(*b*)	Volume per acre
Inches	Number	Feet	Cords
6	5	35	.06
7	25	35	.81
8	40	39	2.08
9	20	41	1.44
10	90	43	8.87
11	25	43	2.94
Total	205	..	16.20

(*a*) Weighted average, 9.1 inches.
(*b*) Weighted average, 41 feet.

Comparative Results

Statistical evaluation of differences in growth shows that in the pure plantings, Scotch pine, red pine, and white pine have grown about equally well in diameter and height, which is considerably better than that of ponderosa pine. In the alternate-row mixture, however, ponderosa pine averaged larger in diameter than white

[5]Gevorkiantz, S. R., and L. P. Olsen (1955). Composite volume tables for timber and their application in the Lake States. U.S.D.A. Tech. Bul. 1104. Table 4, p. 7.

pine, and about equal in height. In mixture, Austrian pine has outgrown white pine in diameter, but lags in height. Norway spruce has grown more rapidly in both diameter and height than the intermixed white pine. In fact, its average height is greater than that of any of the pines.

Practically all trees in each pure and mixed planting have had more than adequate growing space up to the present time. Thus, growth of the individual trees may be considered indicative of site quality on these soils for these species. With more than adequate growing space available in the plantings in the past, the stands do not need thinning. Continued rapid growth of the trees is expected, so the stands should be examined in 1965 to determine the need for thinning at that time.

Live crown length extends to the ground on the Norway spruce. Approximately ¾ of the total height of the white pine is in live crown. Scotch pine and ponderosa pine have the shortest live crowns, with approximately ⅓ of the total tree height in live crown. Ponderosa pine is least vigorous in appearance, having thin, sparse foliage.

Because of the wide spacing, all species have large, persistent branches. Hence, the quality of the stems is coarse. The "open-grown" nature of the trees also has resulted in a high degree of taper in the tree stems.

TABLE 2—White pine stand, 1960

Diameter breast height(*a*)	Trees per acre	Average total height(*b*)	Volume per acre
Inches	Number	Feet	Cords
4	5	25	—
5	15	26	.11
6	—	—	—
7	10	38	.34
8	25	36	1.28
9	30	39	2.06
10	60	40	5.34
11	25	39	2.78
12	15	43	2.23
13	5	40	.16
Total	190	..	14.30

(*a*) Weighted average, 9.2 inches.
(*b*) Weighted average, 38 feet.

TABLE 3—Red pine stand, 1960

Diameter breast height(*a*)	Trees per acre	Average total height(*b*)	Volume per acre
Inches	Number	Feet	Cords
5	20	32	.19
6	5	25	.09
7	10	33	.34
8	55	36	2.67
9	125	40	9.08
10	130	40	11.46
11	35	41	4.03
Total	380	..	27.86

(*a*) Weighted average, 9.0 inches.
(*b*) Weighted average, 39 feet.

For the production of high quality sawlogs in the future, the trees in this widely-spaced planting should have been pruned artificially at an early age. Thus far, there has been no natural pruning. Consequently, the trees are now too large, and the branches are also quite large for artificial pruning. Dead branches on the red pine have decayed more than those on other species and can be broken off easily. However, even these partially decayed branches will persist for many more years.

TABLE 4—Ponderosa pine stand, 1960

Diameter breast height(*a*)	Trees per acre	Average total height(*b*)	Volume per acre
Inches	Number	Feet	Cords
4	10	25	—
5	30	25	.21
6	55	27	.97
7	70	30	2.00
8	35	35	1.67
9	60	34	3.82
10	65	33	4.67
11	5	35	.56
12	10	36	1.18
Total	340	..	15.08

(*a*) Weighted average, 7.7 inches.
(*b*) Weighted average, 31 feet.

TABLE 5—White pine-ponderosa pine mixed stand, 1960

Diameter breast height(*a*)	White pine			Ponderosa pine			Total stand		
	Trees per acre	Average total height(*b*)	Volume per acre	Trees per acre	Average total height(*b*)	Volume per acre	Trees per acre	Average total height	Volume per acre
Inches	Number	Feet	Cords	Number	Feet	Cords	Number	Feet	Cords
4	10	20	—	—	—	—	10	20	—
5	—	—	—	—	—	—	—	—	—
6	10	35	.22	—	—	—	10	35	.22
7	—	—	—	10	32	.28	10	32	.28
8	—	—	—	5	31	.20	5	31	.20
9	5	44	.36	5	37	.36	10	41	.72
10	10	39	.91	10	37	.91	20	38	1.82
11	20	43	2.37	25	36	2.49	45	39	4.86
12	35	44	5.13	15	40	2.04	50	43	7.17
13	5	47	1.04	—	—	—	5	47	1.04
14	5	46	1.22	—	—	—	5	46	1.22
Total	100	..	11.25	70	..	6.28	170	..	17.53

(*a*) Weighted average: white pine, 9.2 inches; ponderosa pine, 10.2 inches.
(*b*) Weighted average: white pine, 37 feet; ponderosa pine, 36 feet.

TABLE 6—White pine-Austrian pine mixed stand, 1960

Diameter breast height(*a*)	White pine			Austrian pine			Total stand		
	Trees per acre	Average total height(*b*)	Volume per acre	Trees per acre	Average total height(*b*)	Volume per acre	Trees per acre	Average total height	Volume per acre
Inches	Number	Feet	Cords	Number	Feet	Cords	Number	Feet	Cords
4	5	21	—	—	—	—	5	21	—
5	—	—	—	5	24	.03	5	24	.03
6	10	32	.22	5	34	.09	15	33	.31
7	15	39	.53	5	35	.20	20	38	.73
8	10	38	.54	15	38	.81	25	38	1.35
9	20	44	1.70	75	37	4.99	95	39	6.69
10	—	—	—	30	39	2.61	30	39	2.61
11	15	44	1.81	30	39	3.19	45	41	5.00
12	5	44	.68	10	40	1.36	15	42	2.04
13	5	44	.82	—	—	—	5	44	.82
Total	85	..	6.30	175	..	13.28	260	..	19.58

(*a*) Weighted average: white pine, 8.6 inches; Austrian pine, 9.3 inches.
(*b*) Weighted average: white pine, 40 feet; Austrian pine, 38 feet.

TABLE 7—White pine-Norway spruce mixed stand, 1960

Diameter breast height(*a*)	White pine			Norway spruce			Total stand		
	Trees per acre	Average total height(*b*)	Volume per acre	Trees per acre	Average total height(*b*)	Volume per acre	Trees per acre	Average total height	Volume per acre
Inches	Number	Feet	Cords	Number	Feet	Cords	Number	Feet	Cords
4	10	22	—	—	—	—	10	22	—
5	10	28	.08	—	—	—	10	28	.08
6	20	28	.31	10	38	.25	30	31	.56
7	—	—	—	10	38	.39	10	38	.39
8	—	—	—	30	37	1.62	30	37	1.62
9	20	41	1.44	10	39	.72	30	40	2.16
10	10	38	.91	10	41	.91	20	40	1.82
11	20	43	2.22	40	44	5.02	60	44	7.24
12	10	37	1.37	10	44	1.36	20	41	2.73
13	10	40	1.64	10	44	1.64	20	42	3.28
14	10	45	2.43	10	51	2.43	20	48	4.86
Total	120	..	10.40	140	..	14.34	260	..	24.74

(*a*) Weighted average: white pine, 9.1 inches; Norway spruce, 10.0 inches.
(*b*) Weighted average: white pine, 36 feet; Norway spruce, 42 feet.

The trees are just entering small sawlog size, and future growth in sawlog volume should be rapid. The quality of the sawlogs, however, will be low because of no pruning.

Of the pines, red pine appears most promising for timber production at this time, with white pine a close second. Scotch pine and Austrian pine are very coarsely-branched, and the ponderosa pine appears to be declining in vigor.

In production of wood volume per acre at age 25, the pure red pine planting ranks highest, with approximately 28 cords per acre. This represents a growth rate of over a cord of pulpwood per acre per year, and is almost the same growth reported for red pine plantings of the same age spaced 6 by 6, 8 by 8, and 10 by 10 feet on a comparable site near Battle Creek, Michigan.[6]

In the white pine-Norway spruce mixture, the spruce has grown over a cord per acre per year on the half of the stand area which it occupies in the mixed planting. Austrian pine also has grown well in mixture with white pine. The white pine has grown better in two of the three mixed plantings than it has in the pure planting.

[6]Lemmien, W. A., and V. J. Rudolph. (1959). Growth and yield of red pine in three spacings. Mich. Agr. Expt. Sta. Quart. Bul. 42: 2 pp. 421-427.

Obviously, volume production has been less than maximum for most species in this widely-spaced planting. Red pine appears to have made the best use of the extra growing space available, after elimination of the chestnut. In addition to reduced volume growth, tree quality is low due to the heavy branching of the trees permitted by the wide spacing.

TABLE 8—Summary of data for pine and Norway spruce plantings, 1960

Species or mixtures	Average diameter breast height	Trees per acre	Average total height	Volume per acre
	Inches	Number	Feet	Cords
Pure plantings:				
Scotch pine	9.1	205	41	16.20
White pine	9.2	190	38	14.30
Red pine	9.0	380	39	27.86
Ponderosa pine	7.7	340	31	15.08
Mixed plantings:				
White pine-ponderosa pine:				
White pine	9.2	100	37	11.25
Ponderosa pine	10.2	70	36	6.28
Total, both species	...	170	..	17.53
White pine-Austrian pine:				
White pine	8.6	85	40	6.30
Austrian pine	9.3	175	38	13.28
Total, both species	...	260	..	19.58
White pine-Norway spruce:				
White pine	9.1	120	36	10.40
Norway spruce	10.0	140	42	14.34
Total, both species	...	260	..	24.74

EXPERIMENTS IN THINNING PEACHES WITH MACHINES[1]

A Progress Report

By H. P. GASTON[2] SCOTT HEDDEN[3] and J. H. LEVIN[3]

WHEN THE FRUIT "SET" is heavy, as it almost always is in well-located, carefully managed orchards, peaches borne by trees that are allowed to carry all of their fruit to maturity seldom attain sufficient size to be of commercial value.

Thinning, i.e., the practice of removing a portion of the fruit early in the season for the purpose of improving that which remains, is the only practical means of bringing about the increase in size essential to the success of a commercial peach growing enterprise.

There are four methods of thinning, but none of them is entirely satisfactory.

Chemical thinning, which involves spraying the trees during the blossom period or the month that follows, is considered impractical by most growers because of the inconsistency of the results. Under some circumstances, a given material may remove an excessive number of the fruits, while under other conditions, the same chemical does not materially reduce the number of peaches. Because of these variations, chemical thinning is used by only a small percentage of growers.

Brush or broom thinning involves sweeping or brushing the blossoms off the trees at about the time they reach the "pink" stage. The results depend, to a considerable extent, upon the judgment and skill of the workman, and very few seasonal farm hands are qualified. It is also true that if brush thinning is followed by adverse weather,

[1]Based on work carried out jointly by the fruit and vegetable harvesting section, harvesting and farm processing branch, agricultural engineering research division, U.S.D.A., and departments of horticulture and agricultural engineering, Mich. State Univ., East Lansing, Mich. The writers wish to express their appreciation to Donald and Ben Barden, of South Haven, to Rodney Bull, of Bailey, and to Ray Pappe, of Ludington, in whose orchards the experiments were conducted.

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[3]Agricultural engineer, agricultural engineering research division, ARS, U.S.D.A.

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which reduces the crop still further, the yield is likely to be low. Because of these facts, many growers consider this method unsatisfactory.

Pole thinning entails separating some of the peaches from the tree (at about the time the pits begin to harden) by striking the branches with a piece of rubber hose attached to a short pole. Good results can be achieved only by experienced thinners, who are usually in short supply. In spite of the fact that the method costs from 35 to 50 cents per tree and has other disadvantages, it is reasonably effective and therefore is widely used.

Hand thinning, which entails removing a part of the crop by hand, takes considerable time and tends to be expensive. Costs usually run from 75 cents to $1 per mature tree. If good results are to be obtained, the work must be done by careful, experienced workmen. Thinners who possess these qualifications are not always available. Although these disadvantages are very real, peaches do have to be thinned and the hand method is used by many growers.

The peach industry is in need of a fast, effective and less expensive method of thinning. Such a method would reduce costs and increase net returns.

PURPOSE OF THE WORK

The purpose of the work was to find out if the mechanical shakers being used to harvest tree fruits could be used to advantage in thinning peaches.

HOW THE STUDY WAS MADE

Eight trees of the Elberta variety, carefully matched on the basis of size and fruit set, were selected in Orchard A, located in North Central Michigan. An equal number of matched Halehaven trees were chosen in Orchard B, located in Southwest Michigan, and a like number of Redhavens in Orchard C, located in the Peach Ridge area. In each case, four of the trees were thinned by hand and four with commercially made shakers (see Fig 1). The time required to do the work was recorded. At harvest time, the fruit borne by all of the trees included in the trials was picked in the conventional manner, i.e., spot-picked twice and stripped the third time over. The fruit harvested at each of the three pickings was separated into size classifications and weighed.

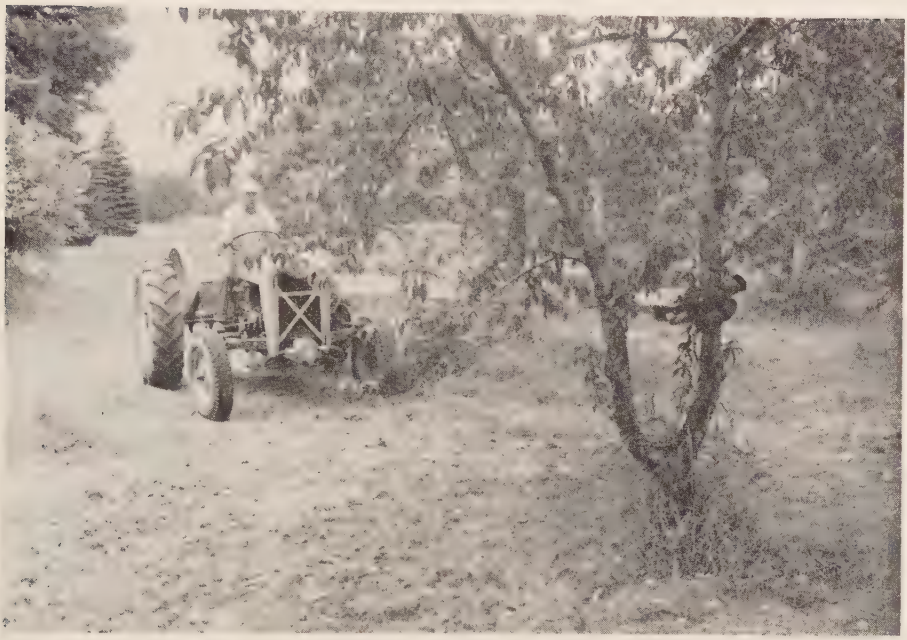

Fig. 1. One of the tractor-mounted hydraulically activated tree shakers used in the trials. Note the separated peaches on the ground.

RESULTS

The time required and the labor cost data for hand and machine thinning are summarized in Table 1. These figures show that while, on the average, it took a crew of two men 28 minutes to thin a tree by hand, the same number of men could do the work in 3.3 minutes (including some supplemental hand thinning of the Elberta trees) when machines were used. The difference in the amount of time required is obviously quite significant.

The average per-tree labor cost of thinning by hand was 93 cents. The comparable figure for the mechanized operation was 8 cents. The per-tree saving amounted to 85 cents—$60 to $90 per acre, depending on planting distance and other variables.

The yield and size data are summarized in Table 2, and presented graphically in Fig. 2. The data shows that the size of the fruit produced by the machine-thinned trees compared favorably with that borne by the hand-thinned trees. The data also indicate that while machine thinning was satisfactory as far as the size of the fruit was concerned, mechanizing the operation reduced yields. The average

reduction amounted to 36 pounds per tree or about 13 percent. In the final analysis, this meant that although mechanization reduced thinning costs, the monetary gain was offset by reduced yields. There is reason to believe, however (as will be explained later) that improved thinning techniques will enable growers to achieve satisfactory increases in fruit size without reducing yield.

The tree shaker caused some bark damage on the mechanically-thinned trees. At thinning time, the bark of peach trees is relatively tender and quite susceptible to mechanical damage. Lesser peach tree borers and fungi that cause cankers often attack peach trees at points where the bark has been injured. Valsa canker is one of Michigan's most serious peach tree diseases, and operators who thin with machines should use a well-designed, thoroughly padded claw, and if necessary wrap the points of attachment with rubber belting or other protective material. Every effort must be made to prevent bark damage.

DISCUSSION

While it was not apparent at the time the work was done, as the season advanced it became evident that the tops of the trees on

TABLE 1—Hand thinning and machine thinning compared on the basis of time required

Variety and method of thinning	Number of trees	Number of men in crew	Average time required to do initial thinning (1 tree)	Average time required to do supplemental thinning (1 tree)	Average time required for a crew of 2 to thin 1 tree	Labor cost of thinning 1 tree (wages at $1 per hr.)
			Minutes	Minutes	Minutes	Dollars
ELBERTA						
Thinned by hand	4	2	28.0	0.0	28.0	.93
Thinned with machines	4	2	1.9	5.9	7.8	.26
HALEHAVEN						
Thinned by hand	4	2	30.0	0.0	30.0	1.00
Thinned with machines	4	2	1.2	0.0	1.2	.04
REDHAVEN						
Thinned by hand	4	2	26.0	0.0	26.0	.87
Thinned with machines	4	2	.9	0.0	.9	.03
TOTAL						
Thinned by hand	12	2	28.0	0.0	28.0	.93
Thinned with machines	12	2	1.3	2.0	3.3	.08

TABLE 2—Hand thinning and machine thinning compared on the basis of yield and size of fruit

Variety and method of thinning	No. of trees	Average number of pounds per tree and percentage of fruits of respective size classifications													
		Under 2"		2"-2¼"		2¼"-2½"		2½"-2¾"		2¾"-3"		Over 3"		Total	
		lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%	lbs.	%
ELBERTA															
Thinned by hand	4	0.0	0.0	2.2	.6	66.0	16.8	282.6	72.2	40.0	10.2	.6	.2	392.0	100
Thinned with machines	4	0.0	0.0	1.7	.6	65.5	21.0	227.5	72.7	17.5	5.6	.2	.1	312.5	100
HALEHAVEN															
Thinned by hand	4	0.0	0.0	2.4	1.0	34.2	15.2	144.0	63.9	43.7	19.3	1.6	.6	226.0	100
Thinned with machines	4	0.0	0.0	2.5	1.1	30.2	13.7	128.7	58.3	56.4	25.5	3.0	1.4	220.8	100
REDHAVEN															
Thinned by hand	4	3.2	1.7	50.5	27.3	103.7	55.6	27.7	14.8	1.1	.6	0.0	0.0	186.2	100
Thinned with machines	4	2.3	1.4	25.7	15.7	82.5	50.4	50.0	30.6	3.2	1.9	0.0	0.0	163.7	100
AVERAGE															
Thinned by hand		.3	.4	4.6	6.8	17.0	25.3	37.9	56.6	7.1	11.2	.2	.3	67.0	100
With machines		.2	.3	2.5	4.2	14.8	25.6	33.8	58.4	6.4	11.0	.3	.5	58.0	100

which machines were used had been slightly over-thinned. This was probably due to the ease with which the fruit could be separated —a ½ to 1 second shake was usually sufficient—and the fact that the operators (none of whom had used machines in thinning peaches previous to this time) tended to focus their attention on the lower branches, which were a little harder to thin, rather than on the upper ones from which the fruit separated more readily. The tendency to over-shake the tops apparently led to the reduction in yield.

Experience should enable shaker operators to do from 70 to 90 percent of the work with machines without overthinning the tops. Most of the additional peaches which should come off would probably be located in the lower parts of the trees where they could be reached from the ground and removed by a relatively small crew. Doing most of the work with machines and finishing with poles or by hand would reduce labor costs (as compared to hand or pole thinning methods) without reducing the size of the crop.

If this assumption proves to be true, producers who grow 25 or more acres of peaches will probably find that they are justified in

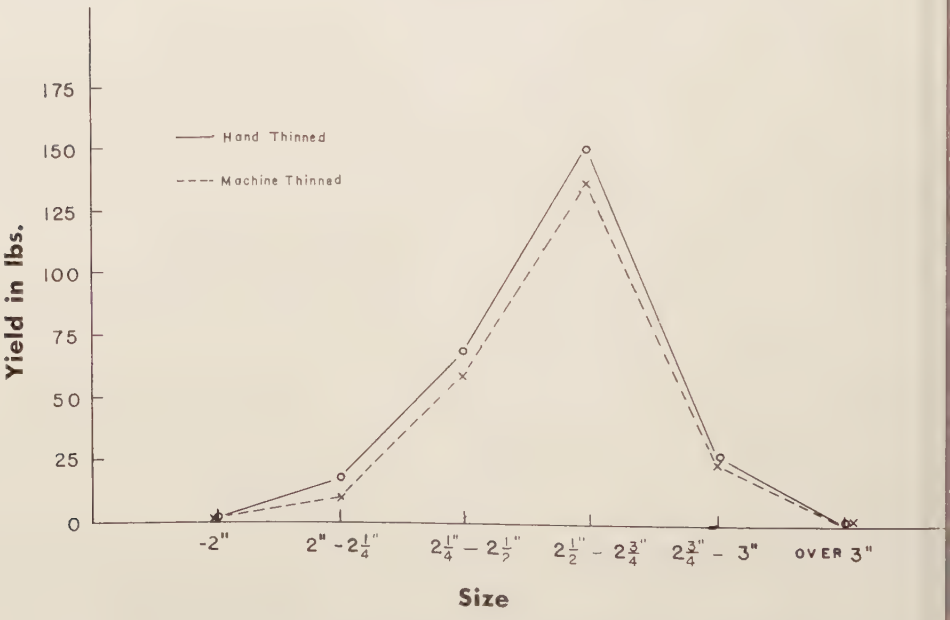

Fig. 2. Hand-thinned and machine-thinned peach trees compared on the basis of yield and size of fruit. (Based on average figures of three varieties taken from Table 2).

purchasing a tree shaker. Other growers may find it possible to rent or lease the necessary equipment or arrange to have the work done on a custom basis.

If maximum benefits are to be achieved, thinning should be done just before the pits begin to harden. Using machines that would make it possible to proceed rapidly enough to thin even large orchards at or near the optimum time would be a great advantage.

The results obtained when peach trees are thinned with machines depend, to a considerable extent, upon the skill of the operator. He should be able to make the necessary "atttachments" to the tree quickly and easily and to separate most of the peaches that should come off without overthinning the tops of the trees.

The writers feel that the results so far achieved warrant continuing the experiment. Some preliminary work indicates that machines can be used to advantage in thinning apples as well as peaches, and arrangements are being made to include both fruits in the 1961 trials.

BASIC DATA RELATED TO THE DRYING OF EAR CORN

By STANISLAW PABIS[1] and CARL W. HALL[2]

INTRODUCTION

THE DESIGN OF EAR CORN DRYERS, as well as many other agricultural dryers, is still done on an empirical basis. From a theoretical and design standpoint, the dryer should be considered as a heat source for a mass-transfer process. Experimental data are required to adapt the theory to a practical dryer design.

The drying of ear corn in deep beds was investigated from 1954 until 1959 in Poland at the Institute of Agricultural Mechanization and Electrification. Equations were developed from the experimental data which can be used to calculate the moisture distribution in a deep layer of the ear corn. The moisture distribution was obtained as a function of the drying time, air flow velocity, humidity, temperature and the initial moisture content of ear corn. The equation is useful in improving the design and management of dryers.

Experiments were carried out at Michigan State University to enable explanation in more detail some of the basic relationships involved in drying of ear corn.

PROCEDURE

The principal areas investigated were:

1. Boundary layer thickness around the ear corn with various air flows
2. Temperature distribution inside the ear corn during drying
3. Moisture movement inside the ear corn during drying

The ears of corn were placed in a vertical position inside the drying chamber. The initial moisture content of the cob and kernels was

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100 and 35 percent, dry basis, respectively (50 and 26 percent, wet basis). The direction of air flow was parallel to the long axis of the ear corn. The boundary layer was related to the heat transfer from air to the ear corn for six air velocities from 34 to 175 f.p.m.

RESULTS

The average boundary layer thickness around the ear corn is represented by equation 1 (Fig. 1):

$$\delta_t = 15.7\ v^{-0.84}$$

where:

δ_t — average boundary layer thickness around the ear corn, inches.
v — air flow velocity parallel to the long axis of the ear corn, f.p.m.

Equation 1 may be written in the form of dimensionless ratios involved in heat transfer. The transfer of heat by convection may be represented by the equation:

$$Nu = A\ Pr^m\ Re^n$$

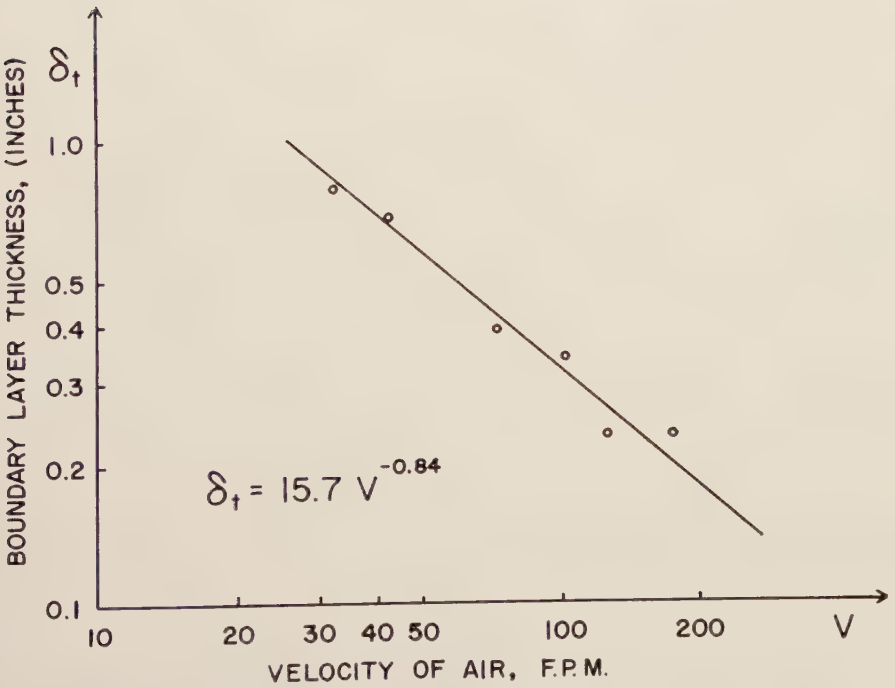

Fig. 1. Effect of velocity of air on boundary layer of ear corn.

where:

Nu — Nusselt's number, $\frac{hD}{k}$

Pr — Prandtl's number $\frac{c\mu}{k}$

Re — Reynold's number, DV $\frac{\rho}{\mu}$

A, m, n — constants

where:

h — coefficient of convection heat transfer
V — velocity
δ_t — film thickness
c — specific heat
k — conductivity coefficient of heat transfer
μ — viscosity

The following equation 2 is obtained:

$$\frac{D}{k} = 1.14 \times 10^{-3} \, Re^{0.84}$$

where D, ft., is the average diameter of the ear corn.

The temperature distribution was measured at eight points inside of the ear of corn and on the surface. Measurements were taken with moisture contents of 0, 37.9, 54.9 and 86.5 percent, dry basis, of the ear corn. There are at least four different coefficients of thermal conductivity. The four points of change were at the endosperm, germ, outer part of the cob, and the center of the cob. Moreover, the thermal conductivity changes with the moisture content of the ear corn. It is almost impossible to set up the exact equation for the temperature distribution curves inside ear corn because of the lack of homogeneity of the ear. However, in practice the exact temperature distribution is not necessary, although it can be calculated by the empirical equation 3:

$$Y(\Theta, x, u) = Y_c(\Theta, 1, u)(x^z)^n$$

where:

$$Y(\Theta, x, u) = \frac{t(\Theta, x, u) - t(O, x, u)}{t_o - t(O, x, u)}$$

is a temperature ratio.

Y — temperature ratio of ear corn at time, Θ; position x; and moisture content, u.

$x = \frac{r}{R}$ — a position ratio with R as the radius of the ear corn and r the radius to the position of the temperature measurement.

u — moisture content of the ear corn, percent, dry basis

Θ — time of drying or heating, hr.

t_o — inlet air temperature, deg. F.

$Y_c(\Theta, 1, u)$ — the temperature ratio on the surface (see Equation 5) assumed for further calculations.

n — a power which is a function of the temperature ratio in the ear corn axis.

The temperature ratio in the ear corn axis can be calculated by equation 4:

$$Y(\Theta, O, u) = \tan h\,[1.22\,\Theta\, e^{-0.00945u}]$$

The temperature ratio on the surface of the ear corn assumed for the further analysis can be calculated by equation 5:

$$Y_c(\Theta, 1, u) = 0.65\,Y(\Theta, O, u) + 0.35$$

and the power n by equation 6:

$$n = 0.396\, e^{-4.05\,Y\,(\Theta,\,O,\,u)}$$

Equation 4 gives the temperature distribution at any time in the moisture content between 0 and 90 percent, dry basis, but only for $O \leq x = \frac{r}{R} \leq 0.85$. To find the temperature ratio on the surface, equation 7 must be used:

$$Y(\Theta, 1, u) = 0.52\,Y_c(\Theta, 1, u) + 0.48$$

The corresponding points (Θ = constant, u = constant) at $x = 0.85$ calculated by equation 4 and at $x = 1.0$ by equation 7 are connected with straight lines on the graph: log $Y(\Theta, x, u)$ versus log (x°). The temperature-ratio distribution curves are presented in figures 2, 3 and 4 for three moisture contents.

The moisture movement inside the ear corn was investigated separately. The experiments show that the various parts of an ear of corn and the kernels dry differently (Fig. 5). The moisture content ratio is the moisture content at a certain time divided by the original moisture content. In particular, the germ part of the kernel dries much slower than the endosperm and cob. The ear corn dries faster than the kernels themselves because of the very high rate of drying of the cob. This, however, takes place at the beginning of the drying process.

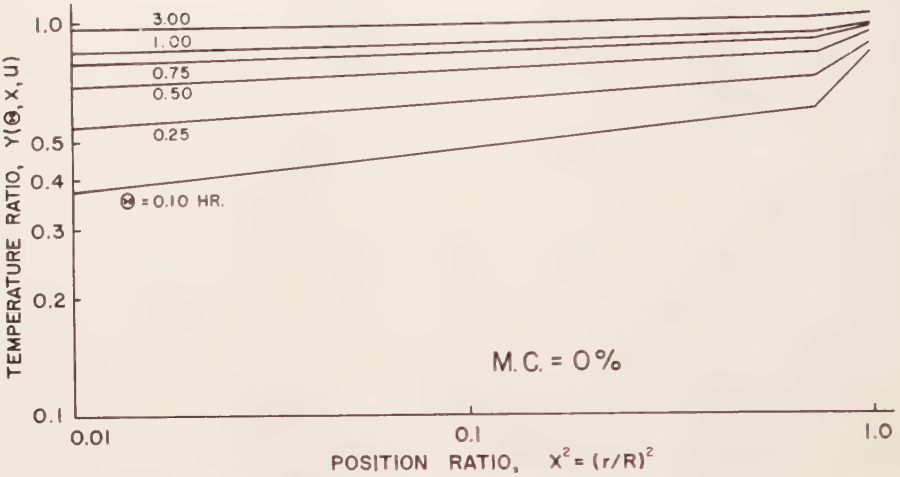

Fig. 2. Temperature ratio as related to position and time for 0% M.C. ear corn.

After about 15 hours of drying with 115° F. air the differences in the moisture content between various parts of the ear corn are not significant. It appears that moisture from the cob moves into the germ to increase its moisture content at the beginning of the drying period.

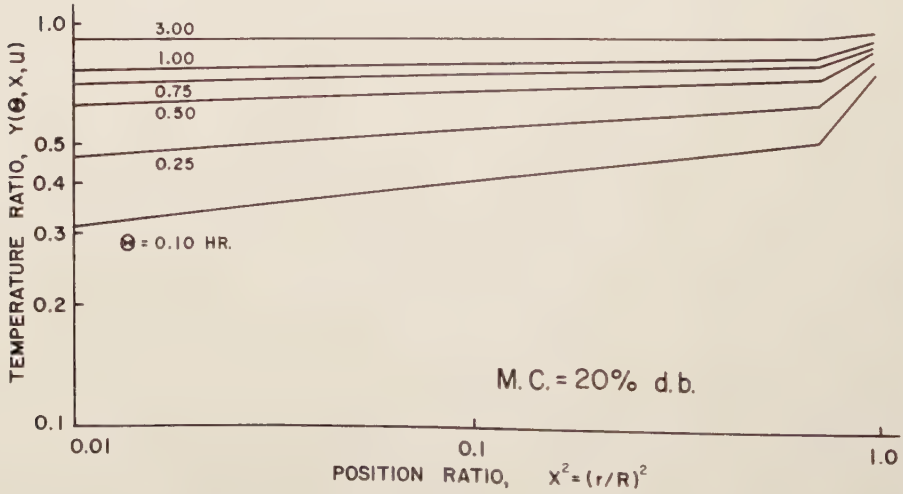

Fig. 3. Temperature ratio as related to position and time of drying for 20% M.C. ear corn.

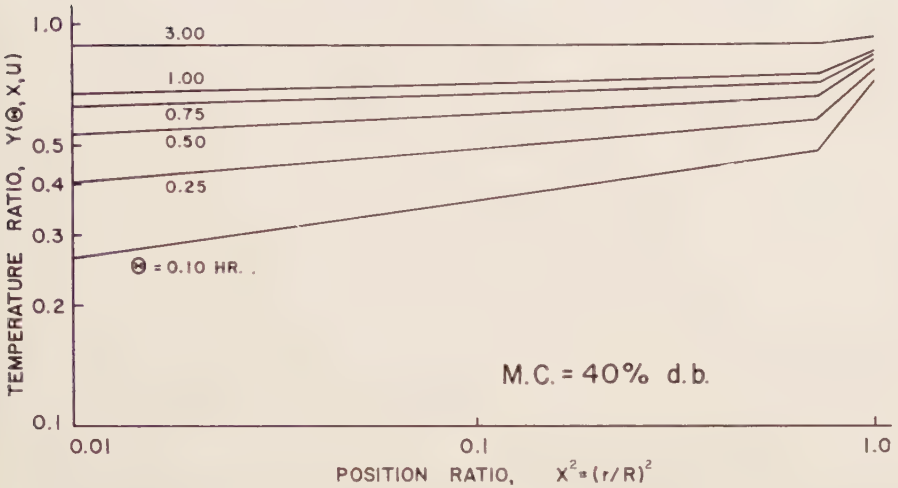

Fig. 4. Temperature ratio as related to position and time for drying 40% M.C., d.b. ear corn.

CONCLUSIONS

The boundary thickness decreases with an increase in air velocity, especially for low velocities. When, however, the air flow velocity is high, i.e. more than about 50 f.p.m., an increase in velocity only

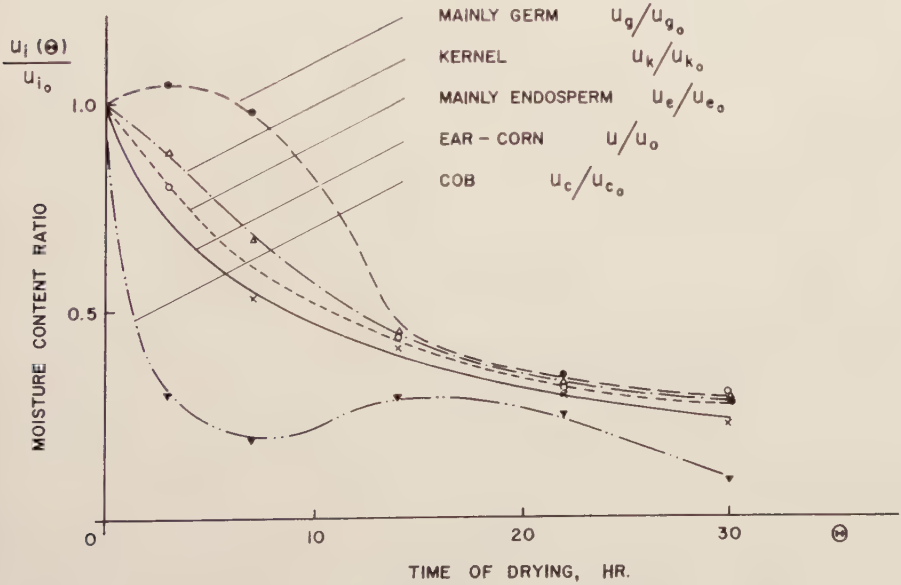

Fig. 5. Drying of various parts of ear corn using 147 f.p.m. 115° F. air.

slightly affects the boundary layer thickness. This indicates that it is not profitable to increase the air flow velocity over a given range to improve the drying process when drying in a thin layer.

The temperature distribution inside the ear corn can be calculated by equations presented. These equations gave excellent results in comparison with the experimental data.

Although various parts of the ear corn dry differently, the differences in the moisture content, even after a short drying time, are not large and tend to decrease with the time of drying. The initial concentration of water in the cob was higher than the kernels and the water was removed very rapidly from the cob at the beginning of drying. This indicates it probably would not be profitable to use a step-wise process of drying for ear corn.

PROPERTY TAX ASSESSMENT LEVELS IN MICHIGAN[1]

By ARLEY D. WALDO

Department of Agricultural Economics

INTRODUCTION

The general property tax is the major source of revenue for local governments in Michigan. Nearly all of the tax receipts of local governments come from property taxation; and, although local governments receive substantial income from non-tax sources, property taxes comprise the largest single source of the combined tax and non-tax revenues for school district, county, city, and village governments.

Increasing demand for public facilities and services has placed a heavy burden upon the local tax base. Despite the widely recognized faults of the property tax, however, it seems certain that local governments will continue to rely heavily on property tax revenues in the future. Thus, it is essential that the weaknesses of the existing property tax system be corrected, insofar as possible, and that every effort be made to secure equitable treatment for all property owners.

In the broadest sense, the general property tax is a tax on all forms of wealth, both tangible and intangible, levied at a uniform rate according to the prevailing market value of the property. But, in practice, many types of property are wholly or partially exempted from taxation. Moreover, given the legal requirements for property taxation, failure to assess taxable property uniformly results in the inequitable treatment of some property owners.

The primary objective of this study was to ascertain the extent to which certain classes of property are being either over-valued or under-valued by local assessors in Michigan. Although it is generally

[1]This report is based upon the author's M.S. thesis (1960), The general property tax in Michigan: Variations in local assessment levels, department of agricultural economics, Mich. State Univ. Acknowledgment is made to Professor Raleigh Barlowe, who served as advisor to the author in planning and preparing this report. Special thanks are due Mr. Edward W. Kane, Secretary of the Michigan State Tax Commission and his staff for facilitating the collection of the data.

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conceded that there is a wide variation in the average assessment levels of local tax districts, previous studies have not emphasized the variations which exist among the assessment levels of different property classes. A meaningful analysis of assessment data first requires a brief review of the legal and administrative aspects of the Michigan property tax system.

LEGAL AND ADMINISTRATIVE ASPECTS

Legal Restrictions

Michigan's property tax system has its legal basis in various provisions of the State Constitution, in state statutes, and court interpretations of both constitutional and statutory provisions. The Constitution requires that all general property taxes be levied in a "uniform" manner. This stipulation has two effects: First, within each local assessment district, all classes of property subject to ad valorem (according to value) taxation must be taxed at the same rate. Second, the uniformity requirement also necessitates the assessment of all taxable property at the same percentage of actual market value. Assessment is required by the Constitution to be at cash value, which has been further defined as the price which could be obtained for the property in normal market sale.

Numerous classes of property are exempted by law from the property tax. In addition, certain property classes are given special tax treatment for a variety of reasons. Aside from the usual exemptions, the most important exemption in terms of total valuation is intangible personal property. This property class, and others of lesser importance, are subject to specific taxes and, hence, are exempt from the general property tax. The most notable of the other exemptions are those granted to household personal property. Due to the large exemption given to each family, household personal property is, in most instances, completely exempt from taxation.

In Michigan, as in many states, there is a constitutional limit to the general property tax rate. An overall 15-mill limitation is placed upon the aggregate property tax levy of all local governments, excluding municipalities. These 15 mills are normally divided among the county, townships, and school districts. Other rate limitations are imposed upon the tax levies of cities and villages. In all cases, the rate limitations presuppose assessment at true cash value.

Administrative Procedures

Each city and township in Michigan is a separate assessment district for the purpose of property taxation. Township assessment is the responsibility of the elected township supervisor. Municipal governments are free to provide for assessment as they choose, and the assessor is an appointed official in most of the larger cities.

Local assessors are responsible for the assessment of all taxable property at true cash value. If a property owner is dissatisfied with the valuation placed upon his property, the assessment may be appealed to the local board of review which operates in each local assessment district. Further appeal, to the State Tax Commission, is possible if the action of the local review board is unsatisfactory to the appellant property owner. In the absence of fraudulent assessment, cases involving assessment appeal generally will not be heard in the courts.

Equalization of local property assessments is carried out at both the county and state levels. Equalization within the county is necessary for the equitable distribution of taxes levied by governmental units which overlap the boundaries of local assessment districts. Although the state does not levy a general property tax, state-wide equalization is important because most of the legal restrictions on property taxation are now based upon state equalized property valuations. Also, a portion of the state school aid is distributed among local communities on the basis of state equalized valuations.

The state's administrative responsibility in the supervision of property taxation rests primarily with the State Tax Commission, the State Board of Equalization, and the State Board of Assessors. Both boards rely upon the Tax Commission for the performance of administrative and field work. The activities of the Tax Commission consist mainly of property appraisal work necessitated by individual assessment appeals, appeals from the report of county equalization boards, and in the determination of the property valuations recommended to the State Board of Equalization.

Each year the Tax Commission completes detailed equalization studies in about five or six Michigan counties. These studies are based on field appraisals of a 10 to 15 percent sample of the local assessments of each property class within the individual tax districts.

METHOD AND SCOPE

Data

This report presents an analysis of assessment data from 21 Michigan counties. Most of the data were obtained from equalization studies conducted by the State Tax Commission during the period from 1955 through 1959. These studies provided information on the total local assessment valuation and the total state appraisal valuation of each class of real and personal property within each local assessment district.

In all, 20 classes of real property and five classes of personal property were studied. These property classes, which include all major classes of both real estate and personalty, are listed below:

Classes of Real Property

1. Farm improved, 2. farm vacant, 3. timber, 4. part timber, 5. cutover land, 6. suburban acreage improved "B", 7. suburban acreage improved, 8. suburban acreage vacant, 9. suburban platted improved, 10. suburban platted vacant, 11. residential improved, 12. residential vacant, 13. resort acreage improved, 14. resort acreage vacant, 15. resort platted improved, 16. resort platted vacant, 17. business improved, 18. business vacant, 19. industrial, and 20. utility.

Classes of Personal Property

1. Business personal property, 2. industrial personal property, 3. utility personal property, 4. pipelines, and 5. farm personal property.

For the most part, the property classes are self-descriptive. In each case, "improved" real estate includes land upon which buildings are located; while vacant property has no buildings. Homesite property within an incorporated municipality is classified as "residential" real estate, and that located outside of a village or city is classified as "surburban". "Acreages" are parcels of unplatted land of 5 acres or more. Suburban acreage improved "B" real estate includes land of the cutover type, usually parcels of 20 acres or more, used as homesites. "Resort" property is located in areas used primarily for recreational purposes.

Assessment Districts Studied

The study included all of the 320 township and 53 city assessment districts in the following 21 counties: Allegan, Barry, Berrien,

Delta, Eaton, Emmet, Genesee, Gratiot, Ingham, Keweenaw, Luce, Macomb, Menominee, Midland, Ogemaw, Ontonagon, Oscoda, Ottawa, Saginaw, Shiawassee, and Van Buren.

In the analysis, the townships were classified as predominately rural, urban, or resort districts, according to the composition of their real estate tax base. The 320 townships were divided as follows: 209 rural townships, 74 urban townships, and 37 resort townships.

Both size and composition of the property tax base of the 21 counties varied greatly. In 1958, the total state equalized valuations of the counties studied ranged from $7 million in Keweenaw county to $1,185 million in Macomb county. In 1957, real estate accounted for a low of 68.7 percent of the total assessed valuation in Genesee county and a high of 92.4 percent in Ontonagon county. There is, of course, considerable variation in the relative importance of the various property classes among the counties. Still greater diversity is found among the property tax bases of the individual assessment districts.

Measurement of Assessment Levels

The assessment-appraisal value ratio of each property class was used as a measure of the prevailing assessment level of the class. This ratio expresses the total local assessment valuation of all property in a specified class as a percentage of the state appraisal valuation of that property class. Thus, for example, an assessment-appraisal value ratio of 50 percent indicates that the local assessment valuation of all property in the class is 50 percent of the state appraisal valuation.

Variations in the assessment levels of the various property classes within an individual assessment district were measured by the difference between the assessment-appraisal value ratio of each property class and the average ratio for all real property or all personal property in the district. In order to compare the assessment levels with those of other districts, the assessment-appraisal value ratios were adjusted to the equivalent of a 100 percent assessment for the total real estate valuation, and for the total personal property valuation, in each district. Thus, an adjusted ratio of 100 percent indicates that the property class being considered is assessed at the same proportion of the state appraisal valuation as the average of, say, all real property in the district. An adjusted ratio of less than

100 percent means that the property class is under-assessed relative to the average assessment level, and an adjusted ratio of more than 100 percent is indicative of over-assessment.

VARIATIONS IN LOCAL ASSESSMENT LEVELS

Township Assessment Districts

Average Assessment Levels. Although assessments are supposed to be at cash value, there are substantial variations in the average assessment levels of the local districts. The State Tax Commission tries to appraise the properties it examines at 50 percent of their current market values. And the average assessment levels of all property included in the study ranged from 18.4 percent to 101.8 percent of the state appraisal valuations in the 320 townships. In general, the local assessment levels were about 50 percent of the state appraisal valuations; however, the median assessment level for the 74 urban townships was somewhat below the median assessment levels for the rural and resort townships. The average assessment levels of personal property varied much more than those of real estate.

A comparison of the average assessment levels of real and personal property revealed that real estate was assessed at a higher percentage of cash value than was personal property in 196 of the 320 townships.

Real Estate Assessments. There were wide variations in the assessment levels of each class of real property; but certain property classes were, in a substantial majority of the townships, either over-valued or under-valued relative to the average assessment level of all real property in the township. The following analysis excludes the few cases in which the assessment levels were estimated rather than determined by sample field appraisals. In addition, not all townships had property listed under each classification.

The assessment levels of individual property classes indicate the relationship of the local assessment valuations of each class to the average local assessment level of all real property. A median assessment level of 100 percent, for example, means that in the median case the individual property class was assessed at the same percentage of cash value as the average of all real property and that the property class was assessed above and below the average assessment level of all real property (i.e. the 100 percent level) in an equal number of townships.

Farm Real Estate. Among 314 townships, the median assessment level of farm improved real estate was 98 percent (Table 1). For 207 rural townships the median was 97 percent, and 72 percent of the assessment levels in the rural districts were within 10 percentage points of the average real estate assessment levels. Assessments of this property class were less uniform for the resort and urban townships. The median assessment level was 105 percent in the urban townships and 101 percent in the resort townships.

TABLE 1—Adjusted assessment-appraisal value ratios of farm improved and farm vacant real estate, by township group, in 21 selected Michigan counties

Property class and township group	Number of townships	Proportion of sample assessed at:			Median ratio
		Less than 100 percent	More than 100 percent	90 to 110 percent	
		Percent	*Percent*	*Percent*	*Percent*
Farm improved real estate:					
Rural townships	207	63	37	72	97
Urban townships	72	42	58	35	105
Resort townships	35	49	51	28	101
All townships	314	56	44	59	98
Farm vacant real estate:					
Rural townships	207	5	95	14	133
Urban townships	71	15	85	11	141
Resort townships	32	9	91	16	133
All townships	310	8	92	13	134

Farm vacant real estate was over-valued by local assessors in 92 percent of the 310 townships which listed this property class (Table 1). The median assessment level was 134 percent, and over-assessment was prevalent among all three groups of townships. The assessment level of farm vacant real estate exceeded the average real estate assessment level in 95 percent of the rural townships.

Business, Industrial, and Utility Real Estate. Business improved real estate was under-valued by 64 percent of the local township assessors (Table 2). The median assessment level was 92 percent, and under-assessment was evident in all township groups.

Business vacant real estate was also under-valued by local assessors in a majority of the townships. The median assessment level of potential business real estate was 86 percent among all townships (Table 2). Under-assessment occurred in 68 percent of the 53 urban

townships. The median assessment was 79 percent of the average assessment level of all real estate.

Industrial real estate was assessed, in the median case, at 96 percent (Table 2). However, the median assessment level for 106 rural townships was only 92 percent.

TABLE 2—Adjusted assessment-appraisal value ratios of business improved, business vacant, industrial, and utility real estate, by township group, in 21 selected Michigan counties

Property class and township group	Number of townships	Proportion of sample assessed at:			Median ratio
		Less than 100 percent	More than 100 percent	90 to 110 percent	
		Percent	*Percent*	*Percent*	*Percent*
Business improved real estate:					
Rural townships	199	63	37	29	91
Urban townships	73	64	36	41	94
Resort townships	33	78	22	33	93
All townships	305	64	36	32	92
Business vacant real estate:					
Rural townships	79	61	39	16	88
Urban townships	53	68	32	13	79
Resort townships	10	30	70	10	120
All townships	142	62	38	15	86
Industrial real estate:					
Rural townships	106	58	42	21	92
Urban townships	62	50	50	23	100
Resort townships	15	47	53	13	103
All townships	183	55	45	21	96
Utility real estate:					
Rural townships	98	32	68	9	129
Urban townships	50	40	60	14	120
Resort townships	13	23	77	15	145
All townships	161	34	66	11	129

There was, in general, a tendency for local assessors to over-value utility real estate. Among 161 townships, the median assessment level was 129 percent (Table 2), and the assessment level was more than 100 percent in 66 percent of the townships. Over-assessment occurred somewhat more frequently among the rural townships than among the urban townships. In 30 percent of the districts, the assessment level was more than twice the average for all real estate.

Residential Real Estate. The median assessment level of residential improved real estate was 95 percent (Table 3), and the assessment level was less than 100 percent in 64 percent of the 81 townships. In contrast, residential vacant property was assessed at a median level

TABLE 3—Adjusted assessment-appraisal value ratios of residential improved and residential vacant real estate, by township group, in 21 selected Michigan counties

Property class and township group	Number of townships	Proportion of sample assessed at:			Median ratio
		Less than 100 percent	More than 100 percent	90 to 110 percent	
		Percent	*Percent*	*Percent*	*Percent*
Residential improved real estate:					
Rural townships	50	61	39	42	95
Urban townships	28	65	35	53	96
Resort townships	3	100	0	33	88
All townships	81	64	36	46	95
Residential vacant real estate:					
Rural townships	47	42	58	21	107
Urban townships	26	58	42	19	96
Resort townships	3	33	67	33	115
All townships	76	47	53	21	105

of 105 percent. The median level, however, was 107 percent among 47 rural townships and only 96 percent for the 26 urban townships.

Suburban Real Estate. Suburban acreage improved "B" real estate—homesites on cutover lands—was under-valued in 63 percent of the 107 townships (Table 4). The medium assessment level was 94 percent.

Both suburban acreage improved and suburban platted improved real estate were under-assessed in a majority of the townships (Table 4). The median assessment level of suburban acreage improved real estate was 85 percent of the average realty assessment level. The assessment level of this property class was less than 100 percent in 83 percent of the 314 townships. Suburban platted improved real estate was assessed at less than 100 percent in 73 percent of 202 townships, and the median assessment level was 90 percent.

Suburban acreage vacant real estate—potential homesite property—was over-valued in 64 percent of 300 townships (Table 4). But over-assessment was prevalent only in the rural and resort townships where the median assessment levels were 126 percent and 147 percent, respectively. This property class was assessed at more than twice the average level of all real estate in more than 18 percent of the rural and resort townships. In the urban townships, where suburban property valuations made up a large proportion of the realty tax base, the median assessment level was only 97 percent.

TABLE 4—Adjusted assessment-appraisal value ratios of five classes of suburban real estate, by township group, in 21 selected Michigan counties

Property class and township group	Number of townships	Proportion of sample assessed at:			Median ratio
		Less than 100 percent	More than 100 percent	90 to 110 percent	
		Percent	*Percent*	*Percent*	*Percent*
Suburban acreage improved "B" real estate:					
Rural townships	61	64	36	26	93
Urban townships	21	67	33	38	94
Resort townships	25	56	44	28	95
All townships	107	63	37	29	94
Suburban acreage improved real estate:					
Rural townships	206	85	15	28	83
Urban townships	73	81	19	42	89
Resort townships	35	77	23	34	84
All townships	314	83	17	32	85
Suburban acreage vacant real estate:					
Rural townships	196	32	68	14	126
Urban townships	72	54	46	22	97
Resort townships	32	16	84	6	147
All townships	300	36	64	15	121
Suburban platted improved real estate:					
Rural townships	119	74	26	27	88
Urban townships	61	78	22	46	92
Resort townships	22	50	50	23	100
All townships	202	73	27	32	90
Suburban platted vacant real estate:					
Rural townships	116	47	53	15	105
Urban townships	60	75	25	15	80
Resort townships	21	29	71	0	155
All townships	197	53	47	13	96

Suburban platted vacant real estate also was assessed, in the median case, at more than 100 percent in the rural and resort townships and at less than 100 percent in the urban districts (Table 4). The median assessment level in the urban townships was only 80 percent.

Resort Real Estate. Resort acreage improved real estate was undervalued by local assessors in 67 percent of the 151 townships (Table 5), and the median assessment level was 88 percent. The median assessment level of resort acreage vacant real estate was 101 percent, but the median level was only 85 percent in the 18 urban townships.

TABLE 5—Adjusted assessment-appraisal value ratios of four classes of resort real estate, by township group, in 21 selected Michigan counties

Property class and township group	Number of townships	Proportion of sample assessed at:			Median ratio
		Less than 100 percent	More than 100 percent	90 to 110 percent	
		Percent	*Percent*	*Percent*	*Percent*
Resort acreage improved real estate:					
Rural townships	90	64	36	22	86
Urban townships	24	75	25	25	90
Resort townships	37	66	34	30	91
All townships	151	67	33	25	88
Resort acreage vacant real estate:					
Rural townships	75	47	53	7	108
Urban townships	18	67	33	22	85
Resort townships	34	47	53	18	103
All townships	127	50	50	12	101
Resort platted improved real estate:					
Rural townships	57	53	47	25	98
Urban townships	21	33	67	43	106
Resort townships	38	39	61	37	106
All townships	116	45	55	32	103
Resort platted vacant real estate:					
Rural townships	55	51	49	16	99
Urban townships	15	73	27	20	88
Resort townships	34	47	53	41	101
All townships	104	47	53	25	98

Resort platted improved real estate was assessed at a median level of 103 percent, while the median assessment level of resort platted vacant property was 98 percent of the average real estate assessment level.

Timber, Part Timber, and Cutover Lands. Only 21 townships listed timber land, and the median assessment level of this class was within two percentage points of the 100 percent level (Table 6). However, there was a predominate tendency for local assessors to over-value land upon which timber had been partially harvested and cutover lands. The median assessment levels of these property classes were 133 percent and 147 percent, respectively. Land classified as part timber was assessed at more than the 100 percent level in 86 percent of 35 townships, and cutover lands were over-assessed in 93 percent of 106 townships.

TABLE 6—Adjusted assessment-appraisal value ratios of timber, part timber, and cutover lands, by township group, in 21 selected Michigan counties

Property class and township group	Number of townships	Proportion of sample assessed at:			Median ratio
		Less than 100 percent	More than 100 percent	90 to 110 percent	
		Percent	*Percent*	*Percent*	*Percent*
Timber:					
Rural townships	17	53	47	24	95
Urban townships	4	50	50	25	105
Resort townships	0	..	..	..	...
All townships	21	52	48	24	98
Part timber:					
Rural townships	26	15	85	15	130
Urban townships	6	17	83	0	135
Resort townships	3	0	100	33	135
All townships	35	14	86	14	133
Cutover land:					
Rural townships	62	5	95	6	144
Urban townships	21	19	81	14	145
Resort townships	23	4	96	13	165
All townships	106	7	93	10	147

Personal Property. Among the five major classes of personal property in the township assessment districts, business, industrial, and farm personal property were under-assessed in a majority of the townships, and utility personal property and pipelines were generally over-assessed, relative to the average assessment level of all personal property (Table 7). The median assessment levels were 93 percent for business personalty, 80 percent for industrial personalty, and 81 percent for farm personal property. Local assessors under-valued farm personalty in 70 percent of 250 townships. Furthermore, in 25 additional townships the State Tax Commission found that the local tax rolls erroneously listed no farm personal property. In one township, more than $200,000, and in several townships more than $100,000, in farm personalty valuations were added to the local tax rolls as a result of the Tax Commission's field appraisals.

Pipelines were assessed at more than the average of all personal property in 91 percent of the 94 townships which reported pipelines on their tax rolls (Table 7). The median assessment level was 139 percent, and pipelines were assessed at more than 200 percent in 27 percent of the townships.

The median assessment level of the personal property of utilities

was 124 percent (Table 7). Assessments were at more than 100 percent in 70 percent of 248 townships and at more than 200 percent in 19 percent of the local districts.

TABLE 7—Adjusted assessment-appraisal value ratios of five classes of personal property by township group, in 21 selected Michigan counties

Property class and township group	Number of townships	Proportion of sample assessed at:			Median ratio
		Less than 100 percent	More than 100 percent	90 to 110 percent	
		Percent	*Percent*	*Percent*	*Percent*
Business personal property:					
Rural townships	200	57	43	19	93
Urban townships	73	62	38	23	89
Resort townships	28	52	48	14	97
All townships	301	58	42	20	93
Industrial personal property:					
Rural townships	111	69	31	17	77
Urban townships	65	61	39	18	88
Resort townships	13	54	46	0	68
All townships	189	65	35	16	80
Utility personal property:					
Rural townships	169	34	66	21	122
Urban townships	54	20	80	20	140
Resort townships	25	28	72	20	116
All townships	248	30	70	21	124
Pipelines:					
Rural townships	61	12	88	18	136
Urban townships	24	0	100	4	180
Resort townships	9	17	83	56	109
All townships	94	9	91	18	139
Farm personal property:					
Rural townships	168	68	32	22	85
Urban townships	62	73	27	16	64
Resort townships	20	80	20	10	57
All townships	250	70	30	20	81

City Assessment Districts

Average Assessment Levels. Among the 53 cities studied, the average assessment levels of the total valuation of all property ranged from 34.0 percent to 85.8 percent of the state appraisal valuations. There was, however, little difference between the average assessment levels of real and personal property within the individual tax districts. Real property was assessed at a higher percentage of cash value than personal property was in 25 of the 48 cities for which comparable figures were available. The median assessment levels, before adjustment to the 100 percent level, were 52.6 percent for all property, 54.6

percent for real property, and 52.4 percent for personal property. Personal property assessment levels, which varied much more than the realty assessment levels, ranged from 16.2 percent to 126.2 percent of the state appraisal valuations.

Real Property. The bulk of the real estate tax base of the city assessment districts consisted of residential, business, industrial, and utility real estate. The median assessment levels of residential improved, business improved, and industrial real estate were 101 percent, 100 percent and 101 percent, respectively, of the average assessment level of all real estate (Table 8). The uniformity of the assessments in each of these classes is revealed by the percentage of cities in which the assessment levels were in the range of from 90 percent to 110 percent of the average real estate assessment level.

TABLE 8—Adjusted assessment-appraisal value ratios of six classes of real estate and three classes of personal property, for cities, in 21 selected Michigan counties

Property class	Number of cities	Proportion of sample assessed at:			Median ratio
		Less than 100 percent	More than 100 percent	90 to 110 percent	
		Percent	*Percent*	*Percent*	*Percent*
Residential improved real estate	53	47	53	85	101
Residential vacant real estate	53	60	40	23	91
Business improved real estate	53	51	49	45	100
Business vacant real estate	53	62	38	15	84
Industrial real estate	49	48	52	47	101
Utility real estate	38	26	74	8	140
Business personal property	50	42	58	42	105
Industrial personal property	46	63	37	39	90
Utility personal property	39	41	59	15	118

Residential vacant property was assessed at less than 100 percent in 60 percent of the cities (Table 8). The median assessment level was 91 percent. Business vacant real estate was under-valued by 64 percent of the local city assessors, and the median assessment level of this property class was only 84 percent of the average level for all real estate.

Utility real estate was over-valued in 74 percent of the 38 cities for which comparisons were available. The median assessment level was 140 percent.

Personal Property. Assessments of the three major classes of personal property in cities—business, industrial, and utility personal property—were less uniform than the real estate assessments. Business personal property was assessed at more than the 100 percent level in 58 percent of 50 cities (Table 8). The median assessment level was 105 percent. Industrial personal property, assessed at a median level of 90 percent, was under-valued in 63 percent of the cities. The median assessment level of utility personal property was 118 percent, and this property class was assessed at more than the average level of all personal property in 59 percent of the cities.

ASSESSMENT INEQUALITIES

Township Assessment Districts

A summary of the variations in the assessment levels of the 20 major classes of real property, adjusted to the equivalent of a 100 percent assessment for the total real estate tax base of each township, is given in Table 9. It is, of course, unrealistic to expect the assessment levels of all property classes in a district to be exactly 100 percent. When a tolerance of 10 percentage points is allowed, over-assessment is indicated by the proportion of the districts in which the assessment level is more than 110 percent of the average level, and under-assessment is indicated by the proportion in which the level is less than 90 percent. The data show that township assessors tended to over-value cutover lands, farm vacant real estate, and lands upon which timber had been partially harvested; and they tended to under value suburban acreage improved real estate (Table 9).

When a median assessment level of more than 105 percent is taken as indicative of a tendency toward over-assessment, we find that local assessors tended to over-value five classes of real property: (1) cutover lands, (2) farm vacant real estate, (3) part timber land, (4) utility real estate, and (5) suburban acreage vacant real estate. In the same manner, the six property classes assessed at a median level of less than 95 percent could be regarded as generally under-valued (Table 9).

TABLE 9—Adjusted assessment-appraisal value ratios of 20 classes of real estate, for township assessment districts, in 21 selected Michigan counties

Property class	Median ratio	Proportion of sample assessed at:	
		More than 110 percent	Less than 90 percent
	Percent	*Percent*	*Percent*
Cutover lands	147	86.7	3.7
Farm vacant	134	82.5	4.1
Part timber	133	74.3	11.5
Utility	129	60.8	27.9
Suburban acreage vacant(*a*)	121	56.9	28.0
Residential vacant (*a*)	105	45.9	32.8
Resort platted improved(*a*)	103	37.9	30.2
Resort acreage vacant(*a*)	101	44.0	44.1
Resort platted vacant	98	35.5	39.4
Timber	98	33.5	42.9
Farm improved(*a*)	98	20.1	20.9
Industrial	96	35.0	44.3
Suburban platted vacant(*a*)	96	42.1	44.6
Residential improved	95	17.2	37.0
Suburban acreage improved "B"	94	28.0	43.0
Business improved	92	21.7	46.1
Suburban platted improved	90	17.4	50.6
Resort acreage improved	88	22.5	53.0
Business vacant	86	32.9	52.1
Suburban acreage improved	85	7.0	61.1

(*a*) See Table 10.

The median assessment levels of six classes of real estate differed significantly between the rural and urban townships. The data presented in Table 10 suggest that local assessors in predominately rural areas tended to value potential homesite property at higher levels and farm improved real estate at lower relative levels than do assessors in urban districts. These six property classes were all assessed at median levels of more than 100 percent in the resort townships (Table 10).

Comparison of the relative assessment levels of farm improved real estate and suburban homesite property indicates that local assessors tended to over-value farm real estate relative to suburban homesites. The median assessment levels of farm improved real estate were 97 percent for rural townships, 105 percent for urban townships, and 101 percent for resort townships; while the median assessment levels of suburban acreage improved real estate (the largest single

TABLE 10—Median adjusted assessment-appraisal value ratios of six classes of real property, by township group, in 21 selected Michigan counties

Property class	Rural townships	Urban townships	Resort townships
	Percent	*Percent*	*Percent*
Suburban acreage vacant	126	97	147
Resort acreage vacant	108	85	103
Residential vacant	107	96	115
Suburban platted vacant	105	80	155
Resort platted improved	98	106	106
Farm improved	97	105	101

class of suburban homesite property) were only 83 percent for rural townships, 89 percent for urban townships, and 84 percent for resort townships (Table 11). In each case the median assessment level of farm improved real estate was substantially higher than the median of suburban acreage improved real estate.

TABLE 11—Median adjusted assessment-appraisal value ratios of farm improved, suburban acreage improved, and suburban platted improved real estate, by township group, in 21 selected Michigan counties

Township group and property class	Median ratio
	Percent
Rural townships:	
Farm improved real estate	97
Suburban acreage improved real estate	83
Suburban platted improved real estate	88
Urban townships:	
Farm improved real estate	105
Suburban acreage improved real estate	89
Suburban platted improved real estate	92
Resort townships:	
Farm improved real estate	101
Suburban acreage improved real estate	84
Suburban platted improved real estate	100

Variations in the assessment levels of the five major classes of personal property are summarized in Table 12. There was a tendency for local township assessors to over-value pipelines and utility personal property, and to under-value business, farm, and industrial personal property.

TABLE 12—Adjusted assessment-appraisal value ratios of five classes of personal property, for township assessment districts, in 21 selected Michigan counties

Property class	Median ratio	Proportion of sample assessed at:	
		More than 110 percent	Less than 90 percent
	Percent	*Percent*	*Percent*
Pipelines	139	78.6	3.2
Utility personal property	124	60.1	19.3
Business personal property	92	32.8	47.6
Farm personal property	81	19.6	60.8
Industrial personal property	80	2.0	56.4

City Assessment Districts

Table 13 presents a summary of the variations in the assessment levels of the six major classes of real property and the three major classes of personal property in the 53 cities studied. Municipal assessors tended to over-value utility real estate and to under-value residential vacant and business vacant real estate. But industrial,

TABLE 13—Adjusted assessment-appraisal value ratios of six classes of real estate and three classes of personal property, for city assessment districts, in 21 selected Michigan counties

Property class	Median ratio	Proportion of sample assessed at:	
		More than 110 percent	Less than 90 percent
	Percent	*Percent*	*Percent*
Real estate:			
Utility	140	71.0	21.1
Industrial	101	26.5	26.5
Residential improved	101	7.6	7.6
Business improved	100	28.3	26.5
Residential vacant	91	28.3	49.1
Business vacant	84	28.4	56.6
Personal property:			
Utility personal property	118	53.4	30.9
Business personal property	105	42.0	16.0
Industrial personal property	90	10.8	50.0

residential improved, and business improved real estate were assessed, in the median case, very close to the average for all real property.

The data suggest a tendency for local city assessors to over-value utility and business personal property, and to under-value industrial personal property relative to the average assessment level for all personal property.

IMPLICATIONS

The wide variations both within and between the assessment levels of various property classes in the individual local assessment districts have important implications for initial assessment, review of local assessments, and county equalization. It is evident that county equalization boards must do more than adjust the total assessment valuations of each district within the county if all property owners are to be treated fairly. To illustrate the difficulties of county equalization, Eaton county might be taken as an example. It should be noted, however, that an examination of the other counties would reveal substantially the same situation.

Actual assessment-appraisal value ratios for the major property classes in Eaton county (studied by the State Tax Commission in 1958) are given in Table 14. The average assessment levels of all real property ranged from 46.8 percent in Delta township to 77.1 percent in Kalamo township. And the average assessment levels of personal property ranged from 33.9 percent in Sunfield township to 79.0 percent in Kalamo township. This means that personal property in Kalamo township was, as a class, assessed at more than twice the level of personalty assessments in Sunfield township. The overall variations in realty assessment levels ranged from 25.9 percent for business improved real estate in Chester township to 115.1 percent for suburban platted improved real estate in Benton township. Personalty assessment levels ranged from 18.2 percent for business personal property in Delta township to 103.5 percent for farm personalty in Eaton township. It is apparent that equitable taxation cannot be achieved without equalization.

Although equalization can be carried out at any uniform level, assume that the Eaton county board decided to equalize at 100 percent of the state appraisal valuations and upon the basis of average assessment levels of both real and personal property within each local district. The equalization board must first determine the average assess-

TABLE 14—Actual assessment-appraisal value ratios of major property classes in Eaton county, 1958

Assessment district	Classes of real estate								Classes of personal property				
	Residential improved	Business improved	Farm improved	Farm vacant	Suburban acreage improved	Suburban platted improved	Industrial realty	All real estate	Industrial personalty	Business personalty	Utility personalty	Farm personalty	All Personal property
	%	%	%	%	%	%	%	%	%	%	%	%	%
Rural townships:													
Benton	72.9	53.4	69.5	86.0	68.7	115.1		70.6		49.6	64.0	59.4	58.3
Brookfield		79.4	58.8	68.0	54.2			60.1		80.2	76.0	48.3	55.0
Carmel		69.1	70.2	70.5	65.7	58.2		69.2		36.1	72.8	55.1	55.6
Chester		25.9	69.5	91.8	46.8	57.1		69.7		59.9	53.1	50.4	51.9
Eaton		40.5	81.2	81.3	61.1	82.3		71.1		40.5	57.8	103.5	61.5
Eaton Rapids		71.3	75.3	95.0	65.0			75.9		76.1	53.9	64.6	61.4
Hamlin		41.5	57.5	71.3	55.2	49.7		58.6	55.7	71.1	66.6	40.5	53.3
Kalamo		60.0	75.0	112.4	69.5	68.3		77.1		75.6	81.1	77.8	79.0
Oneida		42.2	71.2	86.7	58.9	46.7		65.7	66.2	75.5	59.7	63.5	64.4
Roxand	68.5	50.0	65.4	67.0	53.3			64.5	51.7	29.6	74.1	47.9	51.7
Sunfield	44.6	38.8	54.2	65.8	44.6	48.6		51.4	27.5	36.7	52.6	26.2	33.9
Vermontville	59.2	60.4	68.5	95.6	58.8			67.8	25.9	33.2	64.3	59.7	50.9
Walton		60.9	68.4	83.9	66.5			69.4	58.2	103.1	49.0	62.7	60.1
Windsor	63.8	63.3	65.3	82.9	50.6	54.4		61.5		40.4	61.6	33.1	43.5
Urban townships:													
Bellevue	42.1	47.6	58.4	100.1	40.7			52.4	18.4	38.9	71.3	39.9	45.8
Delta		36.4	50.4	51.0	45.1	47.1		46.8		18.2	65.6	45.0	47.6
Cities:													
Charlotte	66.7	86.5					42.8	68.0	25.9	76.7	69.6		51.9
Eaton Rapids	70.4	72.0					68.7	70.9	36.0	79.6	41.5		52.5
Grand Ledge	61.5	65.7					61.7	62.3	51.0	66.3	48.0		57.9
Olivet	64.1	61.8					67.1	63.5	29.4	40.8	58.7		37.8

ment levels in the districts and then adjust the total realty and total personalty valuations of each district upward to the 100 percent level.

After equalization, the assessment levels in Eaton county would be as shown in Table 15. The average equalized assessment levels of all real property and of all personal property, in each assessment district, are at the 100 percent level; but the variations among the assessment levels of the various property classes persist. How does this affect the distribution of the local tax burden?

First, since it is assumed that the equalization board has correctly equalized the total assessment valuations of the districts, county-wide taxes will be equitably distributed among the local assessment districts. Second, if the board has correctly adjusted both the real estate and the personal property valuations, the taxes in each local district will be equitably divided between real and personal property. Tax inequities still remain, however, among the various property classes. Thus, in Chester township, business improved real estate is paying only 37 percent of its legal tax burden, while farm vacant real estate is paying 132 percent. In Benton township, business improved real estate is taxed at only 76 percent, and suburban platted improved real estate is taxed at 163 percent. Farm vacant real estate is over-taxed and suburban acreage improved real estate is under-taxed in every local district.

The inequities of equalization based upon only average realty and average personalty assessment levels—even when accurately accomplished—are obvious. Moreover, the assessment levels of the property classes omitted from the comparison vary more than those for the major classes, and the inequities are even greater than shown here.

At best, equalization based upon average assessment levels only results in the equitable distribution of the total county valuation among the local assessment districts. Some property classes still bear excessive shares of the tax burden within each district. Equalization cannot eliminate all assessment inequalities, and equalization is not a substitute for uniform local assessment.

CONCLUSIONS

Property owners in Michigan now bear a substantial portion of the burden of financing local governmental units, and it is likely that this burden will increase in the future. Hence, it is essential that the

TABLE 15—Adjusted assessment-appraisal value ratios of major property classes in Eaton county, 1958

Assessment district	Classes of real estate								Classes of personal property				
	Residential improved	Business improved	Farm improved	Farm vacant	Suburban acreage improved	Suburban platted improved	Industrial realty	All real estate	Industrial personalty	Business personalty	Utility personalty	Farm personalty	All Personal property
	%	%	%	%	%	%	%	%	%	%	%	%	%
Rural townships:													
Benton	124.0	75.6	98.4	121.8	97.3	163.0		100.0		85.1	110.0	101.9	100.0
Brookfield		132.4	97.8	113.1	90.2			100.0		145.8	138.2	87.8	100.0
Carmel		99.8	101.4	101.9	94.9	84.1		100.0		64.9	130.9	99.1	100.0
Chester		37.2	99.7	131.7	67.1	81.9		100.0		115.4	102.3	97.1	100.0
Eaton		57.0	114.2	114.3	85.9	115.7		100.0		65.9	94.0	168.3	100.0
Eaton Rapids		93.9	99.2	125.2	85.6			100.0		123.9	87.8	105.2	100.0
Hamlin		70.8	98.1	121.7	94.2	84.8		100.0	104.5	133.4	124.9	76.0	100.0
Kalamo		77.8	97.3	145.8	90.1	88.6		100.0		95.7	102.7	98.5	100.0
Oneida		64.2	108.4	132.0	89.6	71.1		100.0	102.8	117.3	92.7	98.6	100.0
Roxand	106.2	77.5	101.4	103.8	82.6			100.0	100.0	57.2	143.3	92.6	100.0
Sunfield	86.8	75.5	105.5	128.5	86.8	94.6		100.0	81.1	108.3	155.2	77.3	100.0
Vermontville	87.3	89.1	101.0	141.0	86.7			100.0	50.9	65.2	126.3	117.3	100.0
Walton		87.8	98.6	120.9	95.8			100.0	96.8	171.6	81.5	104.3	100.0
Windsor	103.7	102.9	106.2	134.8	82.3	88.5		100.0		92.9	141.6	76.1	100.0
Urban townships:													
Bellevue	80.3	90.8	111.5	191.0	77.7			100.0	40.2	84.9	155.7	87.1	100.0
Delta		77.8	107.7	110.3	96.4	100.6		100.0		38.2	137.8	94.5	100.0
Cities:													
Charlotte	98.0	127.2					62.9	100.0	50.0	148.0	134.3		100.0
Eaton Rapids	99.3	101.5					96.9	100.0	68.4	151.2	78.9		100.0
Grand Ledge	99.0	105.0					99.3	100.0	88.2	114.7	83.0		100.0
Olivet	100.6	97.0					105.3	100.0	77.9	108.1	155.6		100.0

weaknesses of the present general property tax system be minimized.

Most local assessors try to assess properties at some level in the range of from one-fifth to one-third of their current market values. Local assessment valuations are, in most instances, increased in the process of county and state equalization. State equalized valuations now represent about one-half of actual market values.

Inequalities in local assessment valuations are not eliminated in the equalization process. Equalization is not a substitute for uniform local assessment or for the appeal of individual assessment valuations. Moreover, if all property within a given class is assessed at the same level, tax inequities will still exist if the property class is valued at a percentage of current market value which differs from that applied in the valuation of other property classes. For example, among the counties studied the assessment of all farm vacant real estate at exactly the median level of that class would still have treated the owners of farm vacant property unfairly because the median level was more than 30 percentage points above the average assessment level for all real property. Thus, in the median case, these property owners were over-taxed by 30 percent.

Many individuals and groups have taken positions opposing any increase in the 15-mill property tax rate limitation. If an effective limitation on property tax rates is desired, however, equal emphasis must be given to the level of state equalized valuations. Under existing legal requirements, there is nothing, except the discretionary actions of the State Tax Commission and the State Board of Equalization, to prevent the increase of state equalized valuations to levels approaching full market value. This would be the equivalent of approximately doubling the present 15-mill limitation.

It must be concluded that the owners of certain classes of property are receiving inequitable treatment under the current property tax system. Whether these inequities can be reduced more efficiently by employing more trained appraisers within the local districts, conversion to a county-wide assessment system, increased scope of State Tax Commission activities, or in some other way, is subject to further study. Several alternatives are available, and improvements are needed along several lines if equitable treatment of all property owners is to be achieved.

THE MAGNITUDE AND CONTROL OF INSECT POPULATIONS ON RED CLOVER, INGHAM COUNTY MICHIGAN

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Insect injury to roots, foliage, and heads of red clover, *Trifolium pratense* L., has been investigated in many forage and seed producing areas of the United States. Extensive studies concerning the biology, economic importance, and control of the clover root borer, *Hylastinus obscurus* (Marsham), were conducted in 1954 by Gyrisco *et al.* (6) and Newsom (8) in 1948 in New York, and in 1958 by Pruess and Weaver (9) in Ohio. The importance of root feeding injury by clover root curculios *Sitona spp.* in Illinois was described by Bigger (2) in 1930 and estimates of the adult weevil populations were made by Lou and Filmer (7) in 1959 in New Jersey.

The relationship of foliar and head pests to red clover culture has been studied by numerous investigators. Typical of the results of such studies is the extensive report in 1954 of Weaver and King (10) concerning the meadow spittlebug, *Philaenus leucophthalmus* (L.). The association of the clover seed chalcid, *Bruchophagus gibbus* (Bohemian), clover seed midge, *Dasyneura leguminicola* (Lintner) and clover head weevils, *Tychius spp.* with seed and floret injury was reported in 1909 by Folsom (4), in 1961 by Guppy (5), and in 1947 by Arnott (1), respectively.

The present investigation was initiated as part of a comprehensive evaluation concerning the density, distribution, and economic importance of insects associated with red clover in Michigan. The objectives of this phase of the study were to study population trends of foliage, soil, and head infesting species in a limited area, and to evaluate the effects which chemical control of these species had on seed production and plant survival through the second winter.

ARTICLE 43-83

METHODS

General

All experiments were conducted so insect and agronomic data would be obtained starting in the year following seeding (first harvest year). Insecticides were broadcast on experimental fields during the spring of the first harvest year in all experiments except two in which insecticides were mixed with fertilizer and drilled under the seed during seeding.

Roots were examined to assess the feeding injury of the root infesting insects. Meadow spittlebug populations were assayed by recording the number of spittle masses per stem in each plot. Infestation and damage from head infesting insects were recorded by sampling partially mature heads in experiments 1 and 2.

Evaluation of plant survival was made in experiments 1, 3, 4 and 5 by counting living plants in randomly selected square-yard quadrats in each plot.

Seed yield estimates were obtained by combining a 1/20-acre area in experiments 1 and 5 or by cutting and threshing a 1/120-acre area in experiment 4. Yields are reported as cleaned seed per acre.

Data were analyzed according to Duncan (3). In all tables, if treatment means share a common letter they are not significantly different at the 5 percent level; if the means do not share a common letter, they are significantly different.

1958 Experiments

The field used in experiment 1 was located in Ingham County near Mason, Michigan. This experiment consisted of four treatments and a control randomly arranged in three replications. Each plot was 16 feet wide and 450 feet long. The field had been seeded in March of 1957 with Michigan common red clover. Granular formulations of all materials were applied with a Skibby rotary broadcast applicator on April 2, 1958.

Populations of immature spittlebugs were determined on June 5, 1958, by randomly selecting 75 stems from each plot and counting the number of spittle masses per stem. On September 23, 1958, 100 clover heads were randomly selected from each plot. The heads were allowed to dry until October 25 when dissections of the heads and

detailed analyses were made. Dissections were made with the aid of a binocular microscope and the following information was recorded:

1. Good seeds
2. Undeveloped florets
3. Florets with Tychius sp. injury
4. Seeds infested with the clover seed chalcid
5. Florets injured by the clover seed midge.

On October 3, 1958 root samples were removed from each plot and damage estimates of clover root borer populations and incidence of clover root curculio injury were made in the laboratory. Three randomly chosen square yard areas were permanently staked out in each of the 15 plots on June 30 and the number of living plants in each of these areas was recorded on June 30 and October 18, 1958. Seed yields were taken from the plots on October 2 with a combine by harvesting a 7 x 311-foot strip.

The plot arrangement, insecticides, application and sampling techniques for experiment 2 were similar to those described for experiment 1, except that only spittlebug populations were determined.

Experiment 3 was established at the Farm Crops Experimental Farm, East Lansing, to evaluate the effects of insecticides applied with the fertilizer at the time of seeding. Granulated insecticides were mixed with 6-24-12 fertilizer applied at the rate of 400 lbs. per acre. Seedings were made with the band seeder attachment of a John Deere grain drill by placing the seed in a 1-inch band on the surface 1 inch above the insecticide-fertilizer band. Eight pounds of Michigan common red clover were seeded per acre. Seedings were made on April 21, 1958 in 8 x 30-foot plots in four replications. The plots were cultipacked after seeding. Vigor ratings, head counts, yield estimates and plant stands were taken on July 21, August 4, August 21, and September 16, 1959, respectively.

1959 Experiments

Experiment 4 was established on the Farm Crops Experimental Farm, East Lansing, to evaluate the effects of insecticide-fertilizer combinations when applied at seeding. Placement of insecticide, fertilizer, and seed was similar to that in experiment 3. Six treatments and an untreated control were randomly arranged in four

replications, each plot being 7 x 25 feet in size. The granular insecticides were mixed with 0-25-25 fertilizer applied with a grain drill at the rate of 400 lbs. per acre on May 5, 1959. Dollard red clover was band seeded at 8 lbs. per acre over the fertilizer-insecticide bands.

Experiment 5 was established on the Farm Crops Experimental Farm, East Lansing, to evaluate soil, foliage and head infesting insect populations and to ascertain the effects of control on seed yields. A 2.5-acre field of Pennscott red clover, seeded in the spring of 1958, was used for this investigation. A split-plot design with two replications, each 240 x 180 feet, was used. Each replication was divided into two main plots for application of soil insecticides. One of the main plots was treated with granular heptachlor on April 13, using a Gandy Spred-N-Till applicator. Applications were made at the rate of 2 lbs. actual insecticide per acre. The other main plot was not treated. The following four foliar treatments were applied to five plots (24 x 180 feet) in each of the four main plots in the experiment.

1. Thiodan applied with a tractor sprayer on May 15 at the rate ½ lb. actual insecticide per acre from a 2 lb. per gallon emulsifiable concentrate
2. Phorate (Thimet) granules applied with the Gandy applicator on July 5
3. DDT spray applied, as in (1) above, on July 20 at the rate of 1 lb. actual insecticide per acre from a 3-lbs. per gallon emulsifiable concentrate
4. Same as (3) above except an additional spray applied on July 28
5. Untreated check

In an attempt to determine the factors affecting seed production, a series of heads was collected weekly from each plot beginning July 16 and continuing through August 20. In order to insure a relatively uniform stage of maturity among the heads collected, only heads whose florets had started to turn brown were selected. Heads were dried in pint jars and then analyzed following the procedure outlined in experiment 1. Root samples, stand counts, and seed yields were taken in accordance with the procedure outlined in experiment 1. Seed yields were obtained on September 21, 1958.

1960 Experiments

Experiment 6 was designed to compare the effectiveness of granular applications of phosphate materials with chlorinated hydrocarbons

for control of soil insects and the meadow spittlebug. Experimental plots were located near Mason, Michigan, on a field of common red clover seeded in wheat in 1959. Nine treatments and a control were randomly arranged in four replications with each plot 12 x 40 feet in size. Insecticide applications were made on April 19 with a Gandy Spred-N-Till applicator. Spittlebug populations were evaluated on June 4 and roots were dug on September 27 for determination of root insect infestations.

Experiment 7 was located at Michigan State University, East Lansing, in a field of mammoth red clover and was designed to provide additional information regarding the effectiveness of phosphate treatments. Nine treatments and a control were arranged in three replications. Insecticide applications were made on April 28. Spittlebug infestations were assessed on June 6. The rapid decomposition of roots following the seed harvest made it impossible to ascertain the infestations and damage by root infesting species.

RESULTS

Soil Insects and Stand Counts

Extensive and uniform populations of the clover root borer existed in all five experimental fields in which this insect was studied (Tables 1, 2, 3 and 4). Stands measured in spring of the first harvest year were good; however, these gradually declined through the summer and fall (Table 1). Percentages of plants infested with borers in the untreated areas varied from 60 in experiment 4 to 79 in experiment 5. Aldrin, 1 dieldrin, and heptachlor were effective in significantly reducing root borer populations and root damage. There was a trend, though non-significant, toward more effective control with insecticides applied at 2-lb. rates. The extent of damage to clover roots was correlated with the degree of root borer infestation.

There were no significant differences in stand counts made in June and October of the year following seeding (Table 1); however, in October a trend was evident indicating that plots treated with heptachlor had more plants per square yard than those not treated. In the following spring, there were significantly more plants per square yard in the plots treated with heptachlor than in the untreated plots.

When aldrin or heptachlor was mixed with the fertilizer and drilled in a band under the seed row, satisfactory root borer control

TABLE 1—Insect control, seed production, and plant survival of red clover following surface applications of insecticides experiment 1, Mason, 1958

Material(*b*)	Formulation	Percent root borer infestation	Percent roots damaged by clover root curculio	Spittlebug masses per stem	Percent florets infested with clover seed midge	Percent seed infested with clover seed chalcid	Percent seed injured by *Tychius* sp.	Plants per sq. yd.			Pounds seed per acre
								June 30, 1958	October 18, 1958	April 22, 1959	
Phorate.....	2% G(*a*)	36b(*c*)	31b	0.39c	9.5b	6.4a	2.5a	161a	93a	30ab	89a
Heptachlor...	2.5% G	0a	3a	0a	3.3a	6.7a	3.0a	162a	123a	58b	124b
Aldrin.....	2% G	3a	21b	0.23b	4.3a	6.7a	3.5a	143a	92a	47ab	104ab
Dieldren.....	2% G	0a	24b	0.09ab	2.9a	6.6a	1.8a	171a	107a	46ab	95a
Untreated....		67c	23b	0.48c	7.7b	5.5a	2.3a	140a	80a	18a	98a

(*a*) G = Granulated, Emul. = emulsifiable concentrate.
(*b*) All materials applied at the rate of 2 pounds actual toxicant per acre.
(*c*) Means that share a common letter are not significantly different at the 5 percent level; means that do not share a common letter are significantly different.

was obtained through the following year (Table 2). In a similar experiment, in which insecticide-fertilizer mixtures of heptachlor, dieldrin, and aldrin were drilled under the seed row (Table 6), there were more living plants in plots treated with heptachlor than in those not treated. It was evident from observations in untreated plots that the decline of plant numbers from spring to fall, during the year following seeding, followed the expected pattern of seasonal decline due to diseases and competition. Root boring insects appeared to accentuate this decline, for in plots where they were partially controlled, plant survival was highest (Table 1).

TABLE 2—Clover root insect control and plant survival of red clover treated with insecticide-fertilizer mixtures drilled in bands under the seed row experiment 4, East Lansing, 1959-60

Treatment	Formulation	Pounds toxicant per acre	Clover root borer		Clover root curculio		Plants per sq. yd.
			Percent of plants infested	Mean damage per root(a)	Percent of plants damaged	Mean damage per root(a)	
Heptachlor...	5% G	1	2.5a	0a	70.0bc	1.6abc	64.5a
Heptachlor...	5% G	3	2.5a	0.1a	37.5a	0.6a	50.5a
Aldrin.....	5% G	1	5.0a	0.2a	72.5bc	2.0bc	50.0a
Aldrin.....	5% G	3	0a	0a	52.5ab	1.0ab	45.3ab
Phorate.....	10% G	1	60.0b	1.9b	90.0c	2.1c	26.0c
Phorate.....	10% G	3	80.0b	2.5b	90.0c	2.5c	27.5bc
Untreated ...	.....	..	60.0b	2.0b	95.0c	2.3c	25.3c

(a) Rating based on feeding scars and root decomposition, with increasing damage from 0 to 5.

Feeding injury by larvae of the clover root curculio ranged from 95 percent (Table 2), to 23 percent (Table 1), in the untreated plots. There was a reduction in the number of plants injured as well as severity of injury in the aldrin and heptachlor plots. Even in the most effective treatments, external root injury was evident.

Foliar Insects

An evaluation of meadow spittlebug populations was made in experiments 1, 2, 5, 6 and 7 (Table 5). Infestations in the untreated plots varied from 0.48 to 1.49 masses per stem. These populations were consistently below the numbers generally reported as being of sufficient magnitude to warrant commercial control. The broadcast soil applications of heptachlor, aldrin, dieldrin, and Thiodan were generally effective in reducing spittle masses. There was a general increase in the effectiveness in the 2 over the 1-lb. rates. Applications of Amer-

TABLE 3—Insect control, seed production and plant survival of red clover following surface applications of insecticides experiment 5, East Lansing, 1959

Treatment	Formulation	Pounds toxicant per acre	Percent root borer infested roots	Spittlebug masses per stem	Percent florets infested with clover seed midge	Percent seed infested with clover seed chalcid	Percent seed injured by *Tychius* sp.	No. of *Tychius* sp. emerged per dried head	Plants per sq. yd.		Heads per sq. ft.		Pounds seed per acre
									July 8, 1959	October 2, 1959	July 30, 1959	August 18, 1959	
Soil													
Heptachlor	2.5% G	2	0	0	3.9a	3.6a	0.6a	0.3a	55a	32a	20a	33a	91a
Untreated	.....	..	79	0.66	7.9b	2.2b	3.8b	5.3b	52a	31a	15b	28b	74b
Foliar													
Thiodan(*a*)	2# Emul.	0.5			6.2b	3.2bc	3.3b	3.8a	57ab	29a	15a	34a	78a
Phorate	5% G	2			5.0a	2.4a	1.4ab	1.0(*b*)	61b	33a	17ab	31a	83a
DDT 1-application	3# Emul.	1			5.4a	2.3a	1.0a	1.6a	48a	31a	19b	31a	90a
DDT 2-applications	3# Emul.	1			7.4c	2.9ab	2.7ab	3.3a	54ab	30a	17ab	27a	84a
Untreated	.....	...			5.2a	3.6c	2.4ab	2.4a	61b	36a	18ab	31a	78a

(*a*) 6,7,8,9,10, 10 hexachloro-1,5,5a,6,9,9a hexahydro-6, 9-methano-2,4,3-benzodioxathiepin-3-oxide.
(*b*) Not analyzed statistically.

TABLE 4—Clover root insect control following surface applications of insecticides to red clover, experiment 6, Mason, 1960

Treatment	Formulation	Pounds toxicant per acre	Clover root borer		Clover root curculio	
			Percent of plants infested	Mean damage per root(*a*)	Percent of plants damaged	Mean damage per root(*a*)
Heptachlor	5% G	1	2.5a	0a	55.0abc	1.1ab
Heptachlor	5% G	2	0a	0a	40.0a	0.8a
Heptachlor	5% G	4	0a	0a	47.5ab	0.6a
Aldrin	5% G	1	12.5a	0.3a	82.5bcd	2.7c
Aldrin	5% G	2	5.0a	0.1a	27.5a	0.8a
Am. Cy. 18133(*b*)	5% G	1	50.0b	2.0b	87.5cd	3.0c
Am. Cy. 18133	5% G	2	52.5b	1.6b	82.5bcd	2.5bc
Ethion	5% G	2	52.5b	1.8b	72.5bcd	2.7c
VC-13	5% G	2	67.5b	2.1b	90.0cd	3.4c
Untreated	.....	..	75.0b	2.7b	92.5d	3.6c

(*a*) Rating based on feeding scars and root decomposition, with increasing damage from 0 to 5.
(*b*) 0, 0-diethyl 0-2-pyrazinyl phosphorothioate.

ican Cyanamid 18133 resulted in limited reductions of spittle masses. This was the only phosphate material which produced a reduction in spittlebug infestations.

Head Infesting Insects and Seed Yield

Populations of the clover seed midge, clover seed chalcid, and clover head weevil were determined in experiments 1 and 5, (Tables 1 and 3). These three species were consistently present in low densities in these two experiments. Approximately 5.5 percent of the

TABLE 5—Meadow spittlebug control following surface application of insecticide to red clover in five experiments, Ingham county, 1958-60

Material	Formulation	Pounds toxicant per acre	Mean masses per stem and experiment number				
			1958		1959	1960	
			1	2	5	6	7
Heptachlor	5% G	1				0.16ab	0.02a
Heptachlor	2.5% G	2	0a	0.03a	0		
Heptachlor	5% G	2				0.04a	0a
Heptachlor	5% G	4				0a	
Aldrin	5% G	1				0.76c	0.05a
Aldrin	2% G	2	0.23b	0.16a			
Aldrin	5% G	2				0.45bc	0.01a
Dieldrin	2% G	2	0.09ab	0.03a			
Thiodan	5% G	1					0.01a
Phorate	2% G	2	0.39c	0.57b			
Am. Cyan. 18133	5% G	1				0.75c	0.22b
Am. Cyan. 18133	5% G	2				0.26ab	0.14ab
VC-13	5% G	2				1.24d	0.47c
Ethion	5% G	2				1.27d	0.47c
Untreated			0.48c	0.71c	0.66	1.49d	0.55c

florets examined from untreated plots were injured by the clover seed midge. The clover seed chalcid and clover head weevil ruined approximately 3.4 percent of the potentially good clover seeds in untreated plots.

There was a significant reduction in the larval infestation of the clover seed midge in plots treated with soil applications of aldrin, dieldrin, and heptachlor. It appeared that this reduction was the result of control of first generation larvae as they migrated to the soil for pupation. The results of these studies suggest that second generation adults may not migrate from neighboring fields, or adjacent untreated field areas, to deposit eggs on heads of the second bloom.

The reason for the small but significant increases in florets infested by the clover seed midge, in plots treated with two DDT applications (Table 3), was unexplained.

Seed Yields

There was a small but significantly greater number of heads per square foot in the heptachlor treatment than in the untreated plots (Table 3). A comparable increase in seed yield was also recorded in the same experiment. In experiment 1 (Table 1), there was an increase in the seed yield only in the heptachlor treatment. In experiment 3, (Table 6), plots treated with heptachlor, aldrin, or dieldrin produced significantly more seed than the untreated plot. It appeared that increases in seed yield in these three experiments were the result of accumulative control of soil, foliar, and some head-infesting pests.

TABLE 6—Plant and head counts, vigor and seed production of red clover treated with insecticide-fertilizer mixtures drilled in bands under the seed rows experiment 3, East Lansing, 1958-59

Treatment(c)	Formulation	Heads per sq. ft.	Plants per sq. yd.	Vigor rating(a)	Pounds seed per acre
Heptachlor	2.5% G	24	34	1.2	91a
Dieldrin	2% G	23	27	1.9	79ab
Aldrin	2% G	26	24	3.2	70ab
Thiodan	5% G	18	25	3.2	59b
Phorate	2% G	16	27	3.2	54b
Disyston(b)	5% G	16	24	3.5	50b
Untreated		11	25	3.5	55b

(a) Vigor Rating: 1—uniform stand—minimum weeds; 2—limited barespots—grass showing; 3—approximately equal amounts of clover and weed populations; 4—poor clover stand—abundance of annual weeds and grasses; 5—only scattered clover plants.
(b) 0,0-diethyl S-2-(ethylthio)+ethyl phosphorodithioate.
(c) All materials applied at the rate of 1 pound actual toxicant per acre.

SUMMARY

The following are results of the study associated with the distribution and control of insect populations on red clover during 1958, 1959, and 1960 in Ingham County, Michigan:

1. There were extensive and uniform populations of the clover root borer and clover root curculio in all plots.

2. A 1-lb. application of heptachlor, aldrin, or dieldrin, applied with bands of fertilizer under the seed band during establishment or broadcast in the spring of the first crop year, provided excellent control of the clover root borer and reduced the injury resulting from clover root curculio feeding.

3. There was a consistent decline in plant populations during the 2-year period from establishment until the spring following seed or forage harvest. Significant increases in plant survival and seed yields appeared in several of the chlorinated hydrocarbon treatments, heptachlor being the most effective. Apparently these increases were the result of accumulative control of soil, foliar, and head infesting insects .

4. Phosphate materials (American Cyanamid 18133, VC-13 and ethion) were not effective in control of the soil insect complex.

5. Broadcast soil applications of chlorinated hydrocarbon materials were generally effective in reducing spittle masses. American Cyanamid 18133 resulted in limited reductions of spittle masses.

6. The accumulative damage resulting to the seed or florets from the clover seed midge, clover seed chalcid, and clover head weevil varied from 10 to 20 percent.

7. There was a significant reduction in the larval infestations of the clover seed midge in plots treated with soil applications of aldrin, dieldrin, and heptachlor.

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HEAT PROCESSING CHARACTERISTICS OF FRESH CUCUMBER PICKLE PRODUCTS

III. Heating Rates of Slices

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Sliced fresh cucumber products, known by such familiar names as bread and butter pickles, cross cuts, slices, or chips, are preserved by a pasteurization process. The heating characteristics of the product are an important factor in determining the pasteurization time and, consequently, the size of pasteurizer needed to satisfy the desired production schedule. This paper reports the results of a series of studies to determine the effect of the major processing variables on the heating characteristics of fresh cucumber slices.

Slices are produced by cutting with high-speed knives No. 3 cucumbers (1½ to 2 in. diameter) perpendicular to the long axis of the fruit. The thickness of cut can be varied by changing the speed of the cucumber past the knives, the knife speed, or both. In commercial practice, thicknesses usually range from $\frac{1}{8}$ to $\frac{1}{4}$ in., but exceptions can be found above and below these values. Apart from variations in the spicing, there are two types of covering liquor—a salt-acid brine or a sugar-salt-acid syrup.

Sliced pickle products made using a salt-acid brine present fewer manufacturing problems than sweet-sliced pickles, which require a sugar-salt-acid syrup, because the problems are primarily associated with the behavior of the sugar syrup. If the syrup concentration is high, the heating rate of the product may be drastically reduced and several months may be required for the contents of the jar to equilibrate because of stratification (5).

Too, sugar-salt-acid solutions are corrosive and difficult to remove from equipment. When an overflow syruper is used, syrup adheres to the outside of the jars. Subsequent washing of the jars flushes this

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sugar into the plant effluent where each pound of sugar represents a pound of BOD (biochemical oxygen demand).

Many of these syrup-related problems could be at least partially eliminated by changes in manufacturing procedure. The ideal slice-manufacturing procedure would be a continuous operation. Graded, washed, and blanched cucumbers would be fed into cutting machines. After cutting, imperfect slices would be removed as the product passed over a vibrating screen and the sound slices conveyed directly to an automatic filling machine. This machine would fill each jar with a pre-determined weight of slices. The jars would be filled with the covering liquor in a vacuum syruping machine, capped, and rotated or agitated to insure mixing both before and after pasteurization. The jars then would be stacked in the warehouse upside down and turned right side up on removal to speed equalization.

In many pickle manufacturing plants, slice manufacture is still predominantly a batch or, at best, a semi-continuous operation. The method described by Etchells and Jones (3) is still in use. This involves soaking the cucumber slices from several hours to overnight in a 30° salometer (7.9 percent) brine. Other manufactures simply hold cut slices in a weak salt brine, 3 to 5 percent, from the time the slices are cut until they are ready to be packed.

Controlling the weight of slices in a container is a major problem because the put-in weight affects both the rate of heating and the final sugar and acid level. Placing the syrup or brine in the jar prior to adding slices, called pre-brining or pre-syruping, may be used as an aid in controlling fill. With this method, cucumber slices are added to the pre-syruped jar until the syrup reaches a predetermined distance, usually about 1 inch, from the top of the jar. The final liquid level is obtained by overflow filling of syrup or water followed by head spacing.

Overflow syruping is an expensive operation because significant quantities of syrup adhere to the jar and are wasted. It is possible, by using a more dense syrup, to add the necessary sugar, salt, and acid in the pre-syruping operation and then, after the correct quantity of slices has been added, finish liquid filling with water. Water topping has the advantage of saving sugar and reducing plant effluent BOD. However, the addition of water on top of the syrup insures stratification.

The process variables examined in this study are soaking, covering liquor temperature, holding time between syruping and pasteurization,

covering liquor composition, fill ratio, water topping, and container size. The results have been evaluated in terms of the heating rate (f_h)[1] and lag factor (j).

The heating characteristics of sliced pickle products have received very little attention from researchers. Esselen *et al.* (1) reported heating-rate data for soaked slices in a 4.5 percent acid, 30 percent sucrose syrup in 32-oz. jars and Esselen and Anderson (2) reported data for additional jar sizes. Townsend *et al.* (10) have presented heating rate coefficients for some jar sizes used by pickle manufacturers, whereby known data from one jar size can be used to predict heating characteristics of other jar sizes, thus avoiding the necessity of separate heat penetration measurements.

EXPERIMENTAL

Most of the slice packs were prepared in the laboratory according to the following standard procedure: The cucumbers were cut on a hand-operated slicing machine to thicknesses of 3 16, 7 32, or 1/4 in., depending on the test. They were then packed by hand into the jars to the desired fill ratio, covered with brine or syrup at 130-140°F., closed, and placed immediately in a water bath held at 180°F. Exceptions to this standard procedure are noted under the appropriate test. A few tests were run on commercially packed jars.

The standard sweet liquor was 51 percent sucrose—4.0 percent salt—2.8 percent acetic acid. The standard brine was 1.4 percent acetic acid—5.0 percent salt. Descriptions of all except the novelty jars are given in the two previous papers (8, 9). The novelty jar specifications are: normal fill, 24 oz.; maximum outside diameter, 3.75 in.; height to top of finish, 7.12 in.; jar weight, 13.6 oz.; thermocouple distance from bottom of jar, 1.4 in. Water bath characteristics, temperature measurement, themocouple placement, and data analysis are described in (9).

RESULTS AND DISCUSSION

Table 1 gives the results of tests to determine the effect of soaking the slices in a 5 percent salt solution before packing and subsequent pasteurization; each item is the average from three jars. The control jars (no soaking) were packed according to the standard procedure.

[1]By definition, a large heating rate (f_h) indicates slow heating and a small heating rate (f_h) rapid heating.

TABLE 1—Effect of soaking on sweet pickle slices, ¼-in thick, 0.62 fill ratio, 1956

Heating characteristics	Treatment	JAR					
		16-oz. cylinder	16-oz. vege-table	22-oz. cylinder	24-oz. novelty	28-oz. vege-table	32-oz. regular
Lag factor, j	Not soaked	1.34	1.31	1.12	1.14	1.18	1.31
	Soaked	1.50	1.60	1.36	1.48	1.46	1.43
Heating rate, f_h, min.	Not soaked	32.8	32.6	35.6	36.3	53.3	45.4
	Soaked	32.5	30.2	33.2	33.2	48.3	43.8

The jars with soaked slices consisted of one set of six jars (one for each jar size) containing slices soaked for 3½ hours and two sets of six jars each containing slices soaked for 16 hours. These three sets were combined and treated in the analysis of the data as a single soaking treatment of three replications.

Analysis of the data shows that the lag factor, j, although not significantly different among jars, exhibits a highly significant difference between treatments. By contrast, there is no significant difference in the heating rates between treatments, but the difference is highly significant among jars. The 28-oz. vegetable and 32-oz. regular jars have heating rates significantly different from all other jars and from each other. If the lag factor increases and the heating rate remains constant, then, unless the process is increased, the spoilage fraction in jars of soaked slices will be greater. Because soaking provides a favorable environment for the development of some bacteria, the initial microbial load is greater.

The results of a soaking test, where a 30 percent sucrose concentration was used, are shown in Table 2. This soaking treatment caused no significant difference in either heating rate or lag factor. This result should be contrasted with the results of the previous soaking test with the heavier syrup (Table 1). These data serve to emphasize the fact that results based on one syrup concentration cannot necessarily be applied to other syrup concentrations.

One test was made on sweet slices to compare the heating characteristics of slices covered with the standard sweet liquor to those of slices covered with liquor of the same sucrose concentration but without salt or acid. The purpose of the test was to determine

TABLE 2—Effect of soaking on sweet pickle slices, 30 percent sucrose syrup, ¼-in. slices, 0.62 fill ratio, room temperature brine, 1957

Jar	No. jars in test	Soaking period	Lag factor, j				Heating rate, f_h, min.			
			Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
16-oz. vegetable	6	None	1.06	0.81	1.28	0.20	26.9	25.2	29.0	2.1
	6	Overnight	1.08	0.72	1.28		28.3	25.2	29.2	
32-oz.	6	None	1.36	1.19	1.56	0.15	33.4	28.0	41.0	4.8
	4	Overnight	1.33	1.20	1.59		31.6	26.8	34.6	

whether some short-cuts could be made in the heating rate studies by not having to prepare the more complicated sucrose-salt-acid liquor. Without the acid, such a pack will not, of course, be preserved at the low heat treatments used in fresh cucumber production. Table 3 gives the heating characteristics. No significant differences between the covering liquors was found.

TABLE 3—Effect of absence of salt and acid in the covering liquor on sweet pickle slices, ¼-in. thick, 16-oz. vegetable jar, 30-min. hold, 1957

Covering liquor	No jars in test	Lag factor, j				Heating rate, f_h, min.			
		Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
Standard sweet.....	6	1.25	1.11	1.42	0.17	28.1	23.6	31.0	3.1
50% sucrose only.....	6	1.17	0.99	1.53		31.0	27.2	36.4	

Table 4 shows the effect on heating characteristics of a lower initial temperature of the covering liquor and a 30-min. delay between addition of the liquor and the beginning of the heat treatment. This situation can arise in commercial practice if jars are prebrined and if a jar happens to be delayed on its way to the pasteurizer. The differences in average lag factors and heating rates are significant; the smaller lag factor of the hot-filled jars is favorable to a short process time, but the larger heating rate is not. At the end of a 30-minute process, the hot-filled jars were, on the average, at a slightly higher temperature. The value of the process at the end of 35 minutes in

the bath was the same for both treatments. The results show that there is nothing gained by adding hot brine, provided there is a holding time. However, see Table 5 for the effect of holding time.

TABLE 4—Effect of covering liquor temperature on sweet pickle slices, ¼-in. thick, 16-oz. vegetable jar, 0.62 fill ratio, 30-min. hold, 1957

Covering liquor temperature, °F.	No. jars in test	Lag factor, j				Heating rate, f_h, min.			
		Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
76	6	1.25	1.11	1.42	0.09	28.1	23.6	31.0	2.2
140	6	1.13	1.06	1.23		32.7	31.0	34.4	

Table 5 shows the effects of holding time on the heating characteristics (covering liquor initially at room temperature). The increase in lag factor and decrease in heating rate are significant. In this instance, the effects on the value of the process work in opposite directions so that there is no difference in the accumulated lethality at the end of a 35-minute process. This influence of holding time works to the advantage of the manufacturer, when inevitable delays and other production factors cause the holding time to be variable.

TABLE 5—Effect of holding time on sweet pickle slices, 7/32-in. thick, 16-oz. vegetable jars, 0.62 fill ratio, room temperature brine, 1957

Heating characteristic	Holding time, min.	Ave.(a)	Min.	Max.
Lag factor, j	0	1.11	1.01	1.27
	5	1.16	1.02	1.47
	30	1.25	1.11	1.42
	120	1.50	1.32	2.02
Heating rate, f_h, min.	0	32.2	26.2	37.4
	5	31.0	26.2	33.6
	30	28.1	23.6	31.0
	120	27.1	22.2	30.4

(a) From six jars.

Table 6 shows the effect of a lower sucrose concentration. The lag factor was unchanged, but the heating rate was significantly smaller.

TABLE 6—Effect of covering liquor composition on sweet pickle slices, ¼-in. thick, 16-oz. vegetable jars, room temperature brine, fill ratio 0.62, 1957

Composition percent sucrose-acetic acid-salt	No. jars in test	Lag factor, j				Heating rate, f_h, min.			
		Ave.	Min.	Max.	Std. dev.	Ave.	Min.	Max.	Std. dev.
51—2.8—4.0.....	6	1.11	1.01	1.27	0.15	32.2	26.2	37.4	3.3
30—4.5—4.0.....	6	1.06	0.81	1.28		26.9	25.2	29.0	

Table 7 gives the average heating characteristics of sweet slices in 16-oz. cylinder jars as a function of fill ratio. There was no significant difference among lag factors, but there was a significant increase in heating rate with increasing fill ratio. The range of fill ratio tested (0.62 to 0.84) corresponds to a range in product weight from 10 oz. to 13.5 oz. per 16-oz. jar. This variation is not unrealistic because even a well controlled fill weight may have a standard deviation of 1 oz. This increase in heating rate works to the disadvantage of the processor because tight packs have a higher probability of spoiling.

TABLE 7—Effect of fill ratio on sweet pickle slices, ¼-in thick, 16-oz. cylinder jar, 1959

Heating characteristic(*a*)	Fill ratio				
	0.62	0.66	0.72	0.78	0.84
Lag factor, j.....	1.53	1.44	1.66	1.67	1.57
Heating rate, f_h, min.....	31.0	32.9	34.6	36.2	38.3

(*a*) Average from six jars.

Table 8 gives the results of the water topping tests. Two sucrose concentrations (69 and 50 percent) were tested. The sucrose syrup was added by weight to already packed jars so that, with the addition of 1 oz. (30 ml.) of tap water, the liquid level was at the correct head space. Slices, syrup, and water were all initially at room temperature. Because the slices were cut from extra-large cucumbers, they were cut in half along a diameter before packing. The thermocouple rods used in these tests contained 9 30-gage couples, the junctions of which were spaced ½-in. apart on alternate sides of the rod.

TABLE 8—Effect of water topping on sweet pickle slices, ¼-in. thick, 0.62 fill ratio, 16-oz. cylinder jars, 1961

Liquor composition	Thermo-couple location(*a*)	Number jars	Heating characteristic, ave.		Equalized percent soluble solids
			j	f_h, min.	
69% sucrose	0.9	5	1.53	35.2	
plus	1.4	5	1.52	36.7	27
1 oz. water	1.9	5	1.40	42.6	
	2.4	5	1.33	42.6	
50% sucrose	0.9	3	1.44	29.2	
plus	1.4	3	1.39	32.2	23
1 oz. water	1.9	3	1.29	32.2	
	0.9	3	1.33	31.7	
50% sucrose	1.4	3	1.21	34.0	19
	1.9	3	1.23	33.2	

(*a*) Inches from bottom of jar.

The heating rates in the jars with 69 percent sucrose plus 1 oz. of water were significantly larger. It also should be mentioned that many of the curves in the 50 percent-sucrose-plus-1 oz.-of-water and 50 percent-sucrose-only treatments were broken heating curves. Perhaps more important than the increase in heating rate (depending on the initial sucrose concentration) is the possibility of a low pH at the top of the jar. Two hours after adding the 69 percent sucrose plus water topping (after heating and cooling), the sucrose concentration at the top of the jars was 10 percent. If the jars are to be water topped, pH measurements ought to be made of the liquid in the top of the jar at various times during the heat process.

Table 9 includes some miscellaneous data. The first three items listed in the description column deal with commercially packed sweet slices in 16-oz. jars in which the point measured was farther from the bottom than in the laboratory packs. These data compare to some extent with other data for 16-oz. jars; however, among the three treatments, there were no significant differences in lag factor or heating rate.

Table 10 gives the heating characteristics of slices covered with a salt-acid brine in jars of various sizes. Some of these data and a discussion of them have been given in (6). These results may be contrasted with the results for syrup (Table 1).

Table 11 gives the heating characteristics as a function of position

TABLE 9—Heating characteristics of miscellaneous sweet pickle slice packs

Description	No. jars in test	T.C. setting(*a*)	Fill ratio	Lag factor, j			Heating rate, f_h, min.		
				Ave.	Min.	Max.	Ave.	Min.	Max.
Soaked, 16-oz. cylinder	8	1.7	LP(*b*)	1.36	1.18	1.58	34.6	29.2	37.6
Soaked, 16-oz. cylinder, 30-min hold.	8	1.7	LP(*b*)	1.42	1.27	1.76	33.2	26.0	40.2
No soaking, 16-oz., cylinder	16	1.7	0.72	1.52	1.31	1.80	39.0	34.2	45.2
Half-gallon	4	1.4	0.62	1.27	1.20	1.39	66.1	63.4	68.5
16-oz. vegetable jar 1956 (unknown pre-pasteurization treatment)	18	0.6	0.62	1.49	1.23	1.71	33.5	29.1	39.8

(*a*) Inches above jar bottom.
(*b*) Line pack from pickle plant.

along the central axis of the jar. The objective was to locate the slowest heating point in the jar. The data showed that in each jar, the point of least lethality was located 0.2 of the total liquid height from the bottom of the jar. This point was used in all tests, in the absence of contrary data on the slowest heating point.

The variations in the heating characteristics of slices are all traceable to variations in manufacturing procedure; however, slow heating results only when stratification takes place. When there is only a small amount of stratification, the heating characteristics of sweetened slices may be only slightly different from brine-packed slices. For

TABLE 10—Heating characteristics of 3/16-in. pickle slices in standard brine, 0.62 fill ratio, 1956

Jar	Number jars in test	Lag factor, j			Heating rate, f_h, min.		
		Ave.	Min.	Max.	Ave.	Min.	Max.
16-oz. cylinder	4	1.34	1.20	1.52	19.6	18.3	21.1
16-oz. vegetable	4	1.32	1.27	1.40	19.2	17.0	22.1
22-oz. cylinder	4	1.36	1.17	1.44	23.3	21.0	24.6
24-oz. novelty	4	1.37	1.19	1.47	21.9	21.2	22.7
28-oz. vegetable	4	1.23	1.10	1.41	21.2	19.8	24.6
32-oz. regular	4	1.24	1.12	1.40	23.5	22.1	25.0

TABLE 11—Heating characteristics in different positions in a jar, standard salt-acid brine, 3/16-in. thick, 0.62 fill ratio, 1956

Heating characteristic(a)	Jar	Position (fractional distance from bottom to top of jar)				
		0.0	0.1	0.2	0.4	0.8
Lag factor, j	22-oz. cylinder...	0.92	1.23	1.12	1.23	1.24
	32-oz regular....	1.06	1.21	1.30	1.20	1.15
Heating rate, f_h, min.	22-oz. cylinder...	19.5	19.2	20.0	19.4	17.0
	32-oz. regular....	24.5	24.1	24.5	20.4	13.6

(a) Averages from two jars.

some cases, however, where severe stratification occurs, conduction heating may take place.

The heating rate of slices in a uniform brine or syrup will be substantially different from that in a stratified syrup. For a 16-oz. cylinder jar, the approximate f_h values are 20 min. for slices in brine, 30 min. in a stratified jar with a low brix syrup and over 40 min. with a high brix syrup. The in-going high sucrose syrup will set up the necessary stratification to block convection more quickly than a lower sucrose syrup.

The increase in heating rate which follows from stratification is a function of the osmotic pressure difference across the cell wall. Reducing the osmotic pressure difference, by reducing the pressure outside the cell wall or increasing the pressure inside, should decrease the heating rate. The heating rates of sweet slices reported by Esselen *et al.* (1) and Esselen and Anderson (2) are closer to the heating rates of brine-packed slices than to the heating rates of syrup-packed slices reported in this study. The slices in their tests were held overnight in a 30° salometer (7.9 percent) brine, then packed in a 30 percent sucrose syrup with no salt. Since the calculated osmotic pressures (4) inside and outside the cell wall are approximately equal, presumably there was little net water exchange between the syrup and the cucumber slices, and, therefore, little stratification. A lack of stratification can explain their small f_h values, since it has been shown (7) that the difference in heating rate between a 50 percent sucrose syrup and water is small if there is no stratification.

SUMMARY

These studies of the heating characteristics of sliced fresh cucumber pickles have shown:

1. Increased lag factor for soaked slices when the covering liquor was 50 percent sucrose. However, soaking the slices caused no significant changes in lag factor or heating rate when the sucrose concentration was 30 percent.
2. The combination of covering liquor at room temperature and a 30-minute delay before processing resulted in changes in both lag factor and heating rate, but not in the process value.
3. Holding time had a significant influence on both lag factor and heating rate, but no net effect on process value.
4. An increase in fill ratio caused an increase in heating rate.
5. Depending on the sucrose concentration, water topping caused significant changes in the heating rates.

Each of the above findings is valid only under some processing conditions. There are important departures from these general results depending on jar size, initial temperature of the covering liquor, fill ratio, soaking treatment and liquor composition. A final recommendation is to test each particular pack to insure against some unexpected deviation from the anticipated heating rate.

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VARIETAL VARIATION FOR DORMANCY IN MATURE WHEAT

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INTRODUCTION

Wheat kernels often sprout in the head when harvest weather is wet and humid. The soft white wheat varieties in Michigan are more prone to sprouting in this manner at maturity than are the soft red wheats. This observation is not new, nor is headsprouting a weakness of varieties of recent origin. Nilsson-Ehle (7) reported the same observation in 1914 and it has been since verified by other workers (1, 5, 6).

This paper describes studies with post-harvest dormancy of some wheat varieties currently being grown commercially and others being used in the wheat breeding program at Michigan State University. Methods for breeding sprout resistant wheat varieties will be discussed.

REVIEW OF LITERATURE

Although red wheat varieties in general are resistant to sprouting at maturity, Voss (10), Hutchinson et al. (4), and Wellington and Durham (12) have noted that the red wheat varieties have a variation in dormancy, whereas the white wheat varieties have little or no dormancy or range in dormancy.

Hutchinson *et al.* (4), Harrington (3), and Wellington and Durham (12) have demonstrated greater post-harvest dormancy of unthreshed wheat seed than of comparable threshed seed. Hutchinson *et al.* felt that the glume appeared to facilitate or stimulate the action of some latent factor within the grain itself, rather than some new factor absent in the grain but present in the glume. Wellington and Durham held that the inhibitory effect of the glumes was one of

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competition for free moisture. They postulated that when moisture was limited, reduced germination was due to competition between the glume and kernel for moisture, but when moisture was ample, films of water between the glumes and kernel impeded the diffusion of oxygen to the embryo. Harrington observed that three varieties sprouted readily when tested as threshed seed, but showed several weeks of dormancy when tested with the glumes enclosing the seed. One wheat variety, Karkov, showed no protective effect of the chaff. Smith (9) found that aqueous extracts of wheat chaff were sometimes, but not consistently, effective in inhibiting seed germination.

Scholz (8) did not find the after-ripening period related to spring or winter habit, to earliness, or associated with the moisture content of the grain. Greer and Hutchinson (1) found that nitrogenous manuring had no influence on the dormancy period of wheat. Wellington (11) reported that delayed germination of red grain was not due to the impermeability of the covering layers of the kernel to water, but rather appeared to be determined by the mechanical properties of the covering layers. Miyamoto and Everson (6) demonstrated differences in the catechin and catechin tannin content of red and white wheat varieties and the inhibitory effect of these materials. Since water soluble catechin and catechin tannins are located in the seed coat and are precursors of the water insoluble red pigment, phobaphene, these are suggested as one of the causes of post-maturity dormancy.

PROCEDURE

Varieties and selections of red and white winter wheat were tested for germination using threshed and unthreshed seed. Both series were run at 70°F.

Threshed Seed Tests

A total of five individual germination tests on threshed seed were run at intervals of 0, 5, 10, 15, and 20 days after harvest. Each varietal test sample consisted of 50 seeds which were below 14 percent moisture when harvested. Each sample was placed on a 3½″ x 5″ germination blotter presoaked in a 1/200,000 solution of panogen and water. Panogen was used to control mold. The blotters were folded and put in wooden flats containing 2 inches of moist sand. The flats were then covered to maintain humidity with pieces of

polyethylene plastic held in place by heavy rubber bands. Each flat contained a sample of Genesee as a check.

Each test was read at 3, 5, 7, 10, and 15-day intervals and the readings between these dates were interpolated on the basis of sprout and root growth. In this study, splitting of the seed coat by the swelling embryo was considered germination and 40 percent germination of a sample was considered emergence from dormancy.

Unthreshed Seed Tests

Unthreshed samples of each variety were tested to determine the effect of the glumes on dormancy. Three heads of each variety selected at random were placed in a wooden flat containing 2 inches of moist sand. Three heads of Genesee were used in each flat as a check. The flats were watered as described above. A total of five tests were run, starting at harvest and at 5-day intervals up to and including 20 days. Readings were made at 5, 10, and 15 days after the heads were placed in the germinator and each three-head sample was considered germinated when 10 or more sprouts were visible. This corresponded to the 40 percent level in the previous tests.

A total of 289 varieties and selections were tested for dormancy in 1957, 1958, 1959, and 1960. Complete data for 21 varieties is presented to illustrate the performance of those with the most and the least dormancy and the range of variation.

RESULTS AND DISCUSSION

Post-harvest dormancy readings of threshed and unthreshed seed of 16 red winter wheat varieties for the harvests of 1957-1960 are presented in Table 1. The first six red wheat varieties, Turkey (CI 10016), Turkey (CI 1558), Yga Blondeau, Red Coat, Skandia III B and Hussar, had the most dormancy of the 289 varieties tested. In most years, germination in these varieties was inhibited for 5 or more days when the threshed seed was subjected to high moisture conditions during the period of 2 or 3 weeks following maturity. Hussar seemed to have the weakest dormancy of this group. The seed in the unthreshed heads of these varieties in most tests did not germinate in 15 days nor during a period of up to 3 weeks after harvest.

The 289 selections and varieties tested for post-harvest dormancy constitute a very small sample of the total germ plasm of wheat. It is possible that more extensive testing of world wheat germ plasm

TABLE 1—Number of days of post-harvest dormancy of threshed and unthreshed seed of 16 varieties of red wheat, 1957-1960

Variety	CI number (*a*)	Year	Threshed seed, days after maturity					Unthreshed seed, days after maturity				
			0	5	10	15	20	0	5	10	15	20
			Number of days of dormancy(*b*)					Number of days of dormancy(*c*)				
Turkey	10016	1957	6	6	6	6	3	15+	15+	15+	15+	15+
		1958	6	6	5	5	6	15+	15+	15+	15+	12
		1959	4	5	10	10	5	15+	15+	15+	15+	15+
		1960	15	15	15	10	9	15+	15+	15+	15+	15+
Turkey	1558	1957	6	7	7	7	4	15+	15+	15+	15+	15+
		1958	4	5	5	5	3	15+	15+	15+	15+	15+
		1959	3	5	12	12	7	15+	15+	15+	15+	15+
		1960	13	12	9	10	10	15+	15+	15+	15+	15+
Yga Blondeau (France)		1957	5	5	5	4	3	15+	15+	15+	15+	15+
		1958	5	5	5	5	5	15+	15+	12	12	12
		1959	4	13	11	11	11	15+	15+	15+	10	15+
		1960	15	8	4	6	6	15+	15+	15+	15+	15+
Red Coat	13170	1957	4	5	5	5	3	15+	15+	15+	15+	10
		1958	5	5	5	4	4	15+	15+	15+	15+	12
		1959	6	6	8	6	6	15+	15+	15+	15+	15+
		1960	12	10	6	6	4	15+	15+	15+	15+	15+
Skandia III B (Sweden)		1957	8	15	11	9	4	15+	15+	15+	15+	15+
		1958	4	4	4	4	3	15+	10	12	15+	10
		1959	2	4	8	6	4	10	15	15+	10	15
		1960	9	7	6	4	4	15+	15+	15+	12	15+
Hussar	4843	1957	5	5	4	4	3	15+	15+	15+	15+	15+
		1958	4	5	4	4	4	15+	15+	15+	15+	12
		1959	5	5	4	4	4	15+	15+	15+	15+	15+
		1960	15	15	5	10	4	15+	15+	15+	15+	15+
Seneca	12529	1957	4	4	4	4	3	15	15	10	5	5
		1958	4	4	5	5	5	10	7	7	7	7
		1959	3	4	5	4	4	10	10	10	10	10
		1960	10	7	4	4	4	12	12	10	7	12
Cappelle Desprez (France)		1957	4	5	3	6	3−	12	12	10	10	7
		1958	6	5	5	4	4	12	12	8	8	8
		1959	6	7	7	6	5	10	10	10	10	7
		1960	7	7	6	6	6	12	12	7	7	7
Thorne	11856	1957	6	4	4	4	3	12	12	12	7	5
		1958	3	3	3	3	3	12	8	8	7	5
		1959	3−	4	3−	6	6	10	10	10	10	7
		1960	7	7	4	4	3−	12	7	7	7	12
Dual	13083	1957	4	4	3	4	3	10	10	10	7	5
		1958	4	3	4	3	3	12	12	8	8	4
		1959	3−	6	3−	6	3−	15+	15	15	10	7
		1960	7	5	3	3−	3−	15+	10	7	7	7
Cheyenne	8885	1957	3	4	4	4	2	12	12	12	7	5
		1958	3	3	3	4	3	8	8	8	8	8
		1959	4	2	2	4	2	15	10	10	10	7
		1960	6	6	4	4	2	12	12	12	7	12

(*a*) CI refers to cereal investigation number of the U.S.D.A.
(*b*) Germination in excess of 40% considered emergence from dormancy.
(*c*) Ten sprouts per 3-head sample considered emergence from dormancy.

TABLE 1—Concluded

Variety	CI number (*a*)	Year	Threshed seed, days after maturity					Unthreshed seed, days after maturity				
			0	5	10	15	20	0	5	10	15	20
			Number of days of dormancy(*b*)					Number of days of dormancy(*c*)				
Red Rock	5597	1957	3−	3−	3−	3−	3−	12	12	7	7	5
		1958	3	3	3−	3−	3−	8	8	8	8	4
		1959	4	4	4	4	3−	10	7	15	10	7
		1960	4	4	3−	3−	3−	10	7	7	12	12
Honor	6161	1957	3−	4	3	3−	3−	7	7	7	7	5
		1958	3−	3−	3−	3−	3−	7	4	7	7	4
		1959	3−	3−	4	4	3−	7	5	7	7	7
		1960	4	3−	3−	3−	3−	7	7	7	7	7
Clarkan	8858	1957	3	3	3−	3−	3−	7	8	7	7	5
		1958	3	3	3	3	3	7	8	12	8	7
		1959	3−	3−	3−	3−	3−	7	7	7	7	7
		1960	3	3−	3−	3−	3−	7	7	7	4	7
Knox	12798	1957	3	3	3−	3−	3−	8	8	7	7	5
		1958	3	3	3−	3−	3−	7	8	7	5	4
		1959	3	3	3	3	3	7	7	5	5	7
		1960	4	3−	3−	3−	3−	10	7	7	7	7
Monon	13278	1957	4	4	3	3	3	15	10	10	5+	4
		1958	3	3	3−	3−	3−	8	8	8	8	4
		1959	3−	3−	3−	3−	3−	7	7	5	5	7
		1960	4	3−	3−	3−	3−	7	7	7	4	7

would reveal red wheat varieties with greater post harvest dormancy than that of the varieties in Table 1.

The red wheat varieties Seneca, Cappelle Desprez, Thorne, Dual, and Cheyenne represented a second or intermediate level of dormancy. In most years, germination of the threshed seed of these varieties was inhibited for 4 or more days for a period up to 2 or 3 weeks after maturity. The majority of the red wheat varieties tested fell in this intermediate dormancy group. The seed in the unthreshed heads in this group did not germinate in most tests for 7 or more days nor during a period of 3 weeks after maturity.

Red Rock, Honor, Clarkan, Knox, and Monon are red wheat varieties which appeared to have no inhibitors for germination. Most of the threshed seed samples of these varieties germinated in less than 3 days. The presence of glumes seemed to inhibit germination to a lesser degree than in the intermediate dormancy group.

Post-harvest dormancy readings of threshed and unthreshed seed of five white winter wheat varieties for the harvests of 1957-1960 are presented in Table 2. Of 42 white varieties tested, Brevor was the only line with a measurable degree of dormancy and that was slight.

Figure 1 shows a dormant sample of Red Coat and a non-dormant sample of Genesee 3 days after the germination test was initiated. Note the varietal differences (Fig. 2) in germination on the 10th day of the test with samples which had been stored 20 days. The flat contains the complete range of dormancy shown in Tables 1 and 2.

TABLE 2—Number of days of post-harvest dormancy of threshed and unthreshed seed of five varieties of white wheat, 1957-1960

Variety	CI number (*a*)	Year	Threshed seed, days after maturity					Unthreshed seed, days after maturity				
			0	5	10	15	20	0	5	10	15	20
			Number of days of dormancy(*b*)					Number of days of dormancy(*c*)				
Brevor	12385	1957	4	3	3	3	3	10	7	7	8	7
		1958	3	3	4	3	3	5	8	7	12	5
		1959	4	4	4	4	4	10	7	7	10	7
		1960	4	4	4	4	4	10	5	7	7	10
American Banner	3342	1957	3—	3—	3—	3—	3—	4	6	6	5	5
		1958	3—	3—	3—	3—	3—	4	6	6	6	4
		1959	3—	3—	3—	3—	3—	7	5	5	7	5
		1960	3—	3—	3—	3—	3—	7	7	7	4	4
Yorkwin	11855	1957	3—	3—	3—	3—	3—	4	5	5	5	4
		1958	3—	3—	3—	3—	3—	5	6	6	5	4
		1959	3—	3—	3—	3—	3—	7	5	7	5	4
		1960	3—	3—	3—	3—	3—	7	7	7	4	5
Cornell 595	12372	1957	3—	3—	3—	3—	3—	4	5	4	4	4
		1958	3—	3—	3—	3—	3—	4	6	6	5	4
		1959	3—	3—	3—	3—	3—	5	5	7	5	4
		1960	3—	3—	3—	3—	3—	5	7	5	7	4
Genesee	12653	1957	3—	3—	3—	3—	3—	4	4	4	4	4
		1958	3—	3—	3—	3—	3—	5	6	4	7	4
		1959	3—	3—	3—	3—	3—	7	5	5	5	5
		1960	3—	3—	3—	3—	3—	7	7	7	4	4

(*a*) CI refers to cereal investigation number of the U.S.D.A.
(*b*) Germination in excess of 40% considered emergence from dormancy.
(*c*) Ten sprouts per 3-head sample considered emergence from dormancy.

The variation in dormancy readings within and between years for each variety have several possible explanations. Hardesty and Elliott (2) reported that differences in primary root length and germination of seed from the selection Rio x Rex #41 (CI 12696) were found to be related to the sequence of anthesis and maturation in florets of the parental spike. Florets that reached anthesis earlier (1st and 2nd florets from spikelets in the center of the spike) were found to have the slowest rates of germination. Random seed samples of each variety were used in the present study and since test samples were small, the place of kernel origin on the spike might have caused some of the variation observed in the test.

Annual variations in weather conditions, especially temperature and moisture after the wheat has headed, undoubtedly affect the level of dormancy and the variation in dormancy between years. Seed of the varieties listed in Table 1, which were grown in the greenhouse, were observed to have much higher dormancy levels than those of field-grown material when tested under the same conditions. This could be a result of the lower, more even greenhouse temperatures during the winter. This factor may permit a higher level of inhibitor substances to accumulate in the seed coat of the dormant varieties, or less weathering which would affect seed coat permeability.

The wheat varieties with red seed coats were found to vary over the complete range of dormancy, whereas the varieties with white seed coats have low or no dormancy. Since the association between the red seed coat color in wheat and dormancy is not a complete one, the genes conditioning dormancy must be associated with only one or two, but not all, of the genes for seed coat pigmentation. Miyamoto and Everson (6) discussed the possible relationships of the differences in pigment concentration to differences in germination at maturity. Genetic studies are in progress to determine if this association is due to pleiotropic gene action or linkage.

In wheat breeding programs for varieties with red seed coats or where seed coat color makes no difference, varieties with strong post-harvest dormancy can be readily derived by utilizing the backcross

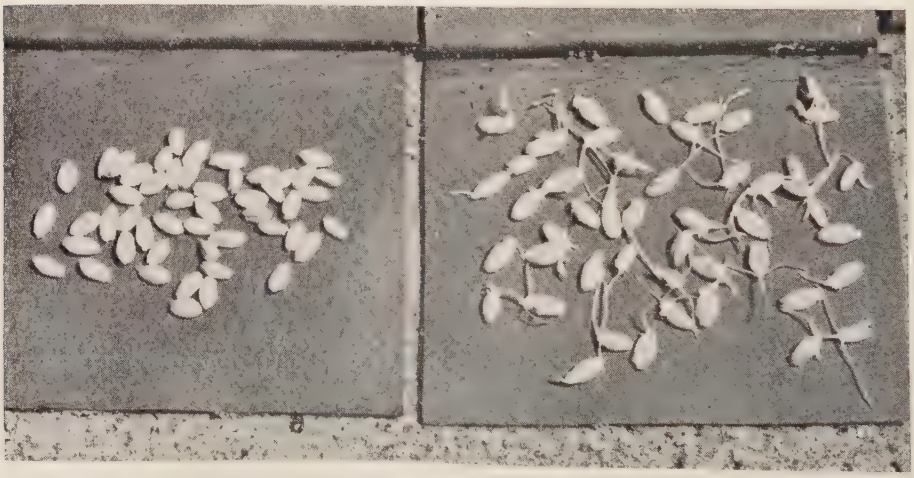

Fig. 1. Threshed seed samples of the dormant red wheat Red Coat (left) and the non-dormant white wheat Genesee (right) 3 days after initiation of germination test on sample stored 20 days.

Fig. 2. Unthreshed seed of red and white wheat varieties showing varietal differences in germination on the 10th day of the test with samples tested 20 days after maturity.

method of breeding. Any of the first six varieties in Table 1 would serve as the donor of the dormancy factor in a cross with an agronomically desirable variety which lacks dormancy. The latter would serve as the recurrent parent. In this situation, neither pleiotropy nor linkage would pose a serious problem for the successful conclusion of the program.

In Michigan, grain merchandisers and processors insist on the preservation of the soft white market class of wheat, since the varieties making up this class have very distinct milling and baking quality characteristics. The breeding of a dormant white wheat variety could present a much more difficult problem. Should linkage and not pleiotropy be involved, a white wheat variety with post harvest dormancy could be bred by using the backcross method of breeding. The cross Red Coat x Genesee, using Genesee as the recurrent parent, is presently being studied. If the linkage were to involve more than one gene pair for dormancy and pigmentation, respectively, recurrent selection along with the backcross method would be necessary.

A most difficult, but certainly not impossible, breeding problem would be encountered should pleiotropy be involved. The initial approach to this problem would be a detailed biochemical study of

the nature of the inhibitory substances occurring in the seed coats of dormant wheat. A breakthrough will occur if naturally-occurring inhibitory substances can be found which are not necessarily involved in the biochemical pathway for the synthesis of phlobaphane, the main pigment in the seed coat of wheat (6). If and when such inhibitory substances are isolated and chemically identified, simple biochemical techniques must be worked out for rapidly detecting their presence in wheat kernels. The breeder will then be required to utilize a biochemical genetic approach to select genes which intensify the dormancy character without intensifying color. Such a biochemical study is now in progress.

SUMMARY

A total of 289 winter wheat varieties and selections were tested in 1957-1959 for post harvest dormancy of threshed and unthreshed seed. Data are presented for 16 varieties with red seed coats and five varieties with white seed coats. The red varieties had post-harvest dormancies ranging from the inhibition of germination for 5 or more days during a period of up to 3 weeks after maturity, to germination in less than 3 days when the threshed seed was subjected to high moisture conditions. All white wheat varieties germinated in less than 3 days after they reached maturity, with the exception of the variety Brevor which had a weak inhibitory system. Methods of breeding for this character are discussed.

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CHEMICAL DEFOLIATION OF CONCORD GRAPES PRIOR TO HARVEST

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Chemical defoliation is practiced commercially on cotton, dry beans and certain nursery crops (1). Recommended materials, concentrations, and methods of application are published for cotton (2), and approximately 50 percent of the cotton crop was treated with chemical defoliants during the 1959 season (6). A similar practice, which could remove the canopy of grape leaves just prior to harvest (Fig. 1) without injuring the fruit or vine, would greatly facilitate picking and also enhance the possibility of mechanical harvesting.

The chemical and physiological events leading to abscission have been studied and reported by various workers (1, 3, 4, 5, 7, 8, 10). Most agree that abscission and defoliation are responses of physiological aging which appear to be hastened by chemical defoliants.

Hall and Lane (4) reported that the respiratory rate of cotton leaves sprayed with the defoliant (Endothal or Shed-a-Leaf) was approximately double that of non-sprayed leaves. They believed rapid hydrolysis and depletion of reserve compounds in the leaf blade and petiole, brought about by the polar translocation of the mobile compounds, also play a prominent role in chemically induced defoliation.

According to Addicott (1), defoliants appear to have the same physiological effect on the petioles as removing the leaf blade; that is, the defoliants produce leaf abscission through injury to the leaf blade and not by direct action on the cells of the abscission zone.

Different materials and concentrations have been found to vary widely in inducing defoliation; however, light applications of relatively mild materials have resulted in the most satisfactory defoliation (1, 5).

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Fig. 1. The top picture shows a non-defoliated Concord vine at time of harvest. The bottom photo illustrates defoliation of a Concord grape vine using a 2 percent solution of Magron (40 percent magnesium chlorate).

Excessive quantities of the favorable chemicals or the use of very caustic materials have caused the leaves to "freeze" onto the plants without resulting in abscission (1, 5).

With the possibility of increasing harvest efficiency, particularly through mechanization, a study was undertaken to determine the effect of some defoliating chemical materials on Concord grape vines applied before harvest, with emphasis on defoliation, berry drop, fruit quality, and winter hardiness of the treated vines.

EXPERIMENTAL PROCEDURE

During the years, 1957-1960, seven possible defoliating chemicals of different concentrations were applied to bearing Concord vines at the Sodus Horticultural Experimental Farm (Table 1). The materials and concentrations used were based on suggested use for commercial defoliation of cotton and other crops, with other materials and concentrations included as more experience was gained.

TABLE 1—Chemicals used in defoliation studies, 1957-60

Material	Concentration (percent)	Trade names of material used	Years used			
			1957	1958	1959	1960
Check (no treatment)	.....	.....	X	X	X	X
Calcium cyanamide	2 (dust)	Aero cyanamid	X			
Ammonium chloride	1	.....	X	X		
Ammonium chloride	2	.....	X	X		
Ammonium chloride	3	.....		X		
Potassium cyanate	1	.....	X	X		
Potassium cyanate	2	.....	X	X		
Disodium 3,6 endoxohexahydro phthalate	1	Endothal	X	X		
Disodium 3,6 endoxohexahydro phthalate	2	Endothal	X	X		
Magnesium chlorate (40%)	1	Magron	X	X	X	X
Magnesium chlorate (40%)	2	Magron	X	X	X	X
Magnesium chlorate (40%)	3	Magron			X	
Sodium chlorate (18.2%)	1	Shed-A-Leaf "L"		X	X	
Sodium chlorate (18.2%)	2	Shed-A-Leaf "L"		X	X	X
Sodium chlorate (18.2%)	3	Shed-A-Leaf "L"			X	
1:1'ethylene—2:2'dipyridylium dibromide	1	Diquat		X		
1:1'ethylene—2:2'dipyridylium dibromide	2	Diquat		X		

Each treatment consisted of three adjacent vines replicated in three locations in the vineyard for a total of nine vines per treatment.

All treatments, except one (calcium cyanamide dust in 1957), were applied as sprays directly to the foliage surface using a 2½-gallon hand pressure sprayer at the rate of 100 gallons per acre after the fruit was considered mature.

The dates and weather conditions at the time of treatment were as follows:

Date	Weather Conditions
September 19, 1957	Clear, warm, no wind, temperature 84°F.
September 23, 1958	Partly cloudy, warm humid, temperature 76°F.
September 16, 1959	Cloudy, cold, windy, temperature 49°F.
September 27, 1960	Partly cloudy, light wind, temperature 70°F.

Visual ratings of defoliation were determined 1 week after application in the following manner: 1 equaled no defoliation, 2-3 was equal to 20-30 percent defoliation, 4-5 equaled 40-50 percent defoliation, 6-8 was 60-80 percent defoliation, 9-10 was considered complete defoliation. The vines of each treatment were evaluated for drop and shriveling of fruit. Percentage soluble solids, reflecting sugar content, was measured by a Zeiss hand refractometer using the juice from four apical berries of each of 25 basel fruit clusters harvested from each plot at the time of defoliation ratings. Fruit samples from each plot were evaluated also for possible off-flavor or other undesirable charcteristics.

RESULTS

The use of chemicals to defoliate Concord grapes, under the conditions of this study, had three major limitations which will be discussed separately: (1) effectiveness of the chemical, (2) berry drop induced by defoliation, and (3) influence of air temperature at time of defoliant application.

Effectiveness of the Chemicals

Magnesium chlorate Magron and sodium chlorate (Shed-a-Leaf "L") were the most effective of the defoliants evaluated (Table 2). Magron at 1- and 2-percent concentrations resulted in good to excellent defoliation (80-90 percent) in all 3 years, 1957, 1958 and 1960 (Fig. 1). Shed-a-Leaf "L" gave only slight to moderate defoliation (30-40 percent) at the 1-percent concentration in 1958, but a 2-percent solution caused moderate to good defoliation in 1958 and 1960. There was no apparent vine injury or undesirable fruit flavor from the use of these two materials. Soluble solids (sugar) of the harvested fruit were not influenced by these or any of the other defoliants (Table 3).

As used, the treatments of ammonium chloride and potassium cyanate were not effective in defoliation and had no adverse effect on the fruit or vine.

Calcium cyanamide dust, used in 1957, resulted in approximately 50 percent defoliation. However, the material was difficult to apply and caused heavy berry drop.

A 1-percent solution of disodium 3, 6 endoxahexahydro phthalate (Endothal) gave moderate defoliation (approximately 60 percent) with a slight amount of berry drop. A 2-percent solution of this chemical resulted in excellent defoliation (80-90 percent) but also caused heavy berry drop and off flavor.

Diquat (1:1′ ethylene – 2:2′ dipyridylium dibromide) used in 1958 at 1- and 2-percent concentrations caused rapid desiccation of the leaves, but no leaf drop, and eventual death of the vines.

Berry Drop Induced by Defoliation

Berry drop (abscission) was associated generally with the degree of defoliation (Table 2). Little drop occurred when defoliation was

TABLE 2—Effect of chemicals on defoliation and berry drop of Concord grapes, 1957-1960

Material	Concentration (percent)	Defoliation rating(*a*)				Fruit drop			
		1957	1958	1959	1960	1957	1958	1959	1960
Check	—	1.0	1.0	1.0	1.0	none	none	none	none
Calcium cyanamide	1	5.3	—	—	—	severe	—	—	—
Potassium cyanate	1	3.3	1.7	—	—	none	none	—	—
Potassium cyanate	2	3.0	3.7	—	—	none	none	—	—
Ammonium chloride	1	1.0	1.0	—	—	none	none	—	—
Ammonium chloride	2	2.0	1.7	—	—	none	none	—	—
Ammonium chloride	3	—	2.0	—	—	—	none	—	—
Disodium 3,6 endoxohexahydrophthalate	1	7.3	5.3	—	—	slight	slight	—	—
Disodium 3,6 endoxohexahydrophthalate	2	9.0	8.3	—	—	severe	severe	—	—
Magnesium chlorate	1	8.0	7.0	5.0	6.6	slight	slight	none	slight
Magnesium chlorate	2	8.6	8.0	4.6	8.0	moderate	moderate	none	slight
Magnesium chlorate	3	—	—	6.0	—	—	—	none	—
Sodium chlorate	1	—	3.7	3.6	—	—	none	none	—
Sodium chlorate	2	—	5.3	3.3	6.6	—	slight	none	slight
Sodium chlorate	3	—	—	3.6	—	—	—	none	—
1:1′ethylene—2:2′dipyridylium dibromide	1	—	(*b*) 7.0	—	—	—	moderate	—	—
1:1′ethylene—2:2′dipyridylium dibromide	2	—	(*b*) 8.0	—	—	—	severe	—	—
	L.S.D.	0.9	1.2	1.3	1.4				

(*a*) See page 833 for method of rating.
(*b*) Killed the vines.

TABLE 3—Influence of chemical defoliants on the soluble solids of Concord grapes, 1957-1960

Treatment		Soluble solids (percent)(a)			
Material	Concentration (percent)	1957	1958	1959	1960
Check	..	16.7	15.2	16.6	12.0
Calcium cyanamide	1	16.5	—	—	—
Potassium cyanate	1	16.6	—	—	—
Potassium cyanate	2	16.9	15.8	—	—
Ammonium chloride	1	16.7	—	—	—
Ammonium chloride	2	16.9	—	—	—
Ammonium chloride	3	—	15.5	—	—
Disodium 3,6 endoxohexahydrophthalate	1	16.5	15.0	—	—
Disodium 3,6 endoxohexahydrophthalate	2	16.5	—	—	—
Magnesium chlorate	1	16.5	14.7	15.5	12.3
Magnesium chlorate	2	16.3	15.3	16.0	12.0
Magnesium chlorate	3	—	—	16.1	—
Sodium chlorate	1	—	14.7	16.5	12.3
Sodium chlorate	2	—	14.7	16.8	—
Sodium chlorate	3	—	—	15.8	—
1:1′ethylene—2:2′dipyridylium dibromide	1	—	15.2	—	—
1:1′ethylene—2:2′dipyridylium dibromide	2	—	14.5	—	—
Significance .05	.....	N.S.	N.S.	N.S.	N.S.

(a) Sample taken 1 week after chemical treatments.

slight. A higher percentage of fruit drop accompanied good defoliation. Where magnesium chlorate was used, however, the drop did not occur until the fruit clusters were disturbed by shaking a trellis wire or by pulling the canes during harvest.

Apparently, similar physiological conditions are responsible for both leaf and fruit abscission. Thus, it may be difficult to induce chemically satisfactory leaf abscission without causing a certain amount of berry drop. At the present time, all grapes in Michigan are harvested by hand. Severe dropping of the berries from chemical defoliation would be very undesirable in a commercial operation. When grapes are harvested mechanically, berry drop, which is now a distinct disadvantage in hand harvesting, may become an advantage. Limited explorations have already indicated that this advantage of berry drop would exist (9).

Influence of Air Temperature on Defoliation

In 1959, Magron and Shed-a-Leaf "L" at concentrations of 1, 2 and 3 percent resulted in less defoliation than in 1957, 1958 and 1960. This reduction in defoliation in 1959 was attributed to the cool air temperature at the time of application. This was shown by a comparison between the air temperature and degree of defoliation of Concord grapes during the 4 years that Magron was used (Table 4). A similar temperature relationship has been reported by Lane and Hall (7) in chemical defoliation of cotton.

TABLE 4—Influence of air temperature on defoliation and berry drop of Concord grapes, using Magron (40% magnesium chlorate), 1957-1960

Concentration of Magron	Date of application	Temperature °F.	Defoliation rating(a)	Amount of berry drop
1%	Sept. 19, 1957	84	8.0	slight
2%	Sept. 19, 1957	84	8.6	moderate
1%	Sept. 23, 1958	76	7.3	slight
2%	Sept. 23, 1958	76	8.0	moderate
1%	Sept. 16, 1959	49	5.0	none
2%	Sept. 16, 1959	49	4.6	none
1%	Sept. 27, 1960	70	6.6	slight
2%	Sept. 27, 1960	70	8.0	slight

(a) Defoliation rating: 1 = no defoliation, 2-3 = 20-30 percent defoliation, 4-5 = 40-50 percent, 6-8 = 60-80 percent, 9-10 = complete defoliation.

DISCUSSION

Many conditions and factors may affect natural or induced defoliation. Addicott (1) lists senescence, disease, injury, low carbohydrate level, drought, high humidity, as well as extremes of air temperature, as some of the factors which will initiate or accelerate abscission.

Much valuable information can be gained from investigations with cotton, bean, and nursery plants. But, these plants are quite different than the grape. Cotton and beans are, for the most part, short lived plants. What happens to them after defoliation is of little consequence. The grape, on the other hand, is a long lived perennial of indeterminant growth characteristics. In terms of physiological age, grape leaves on the same plant vary from the "old", those unfolding early in the spring, to the very young which develop just before harvest. These differences have to be taken into consideration when studying defoliation information derived for different crops.

Finally, as Hall (5) has indicated in his work with cotton, progress in the defoliation of grape vines will certainly be retarded until the basic mechanisms of abscission of grape leaves are more fully understood.

SUMMARY

During the period of 1957 through 1960, various defoliant chemicals were applied to Concord grape vines approximately 1 week prior to harvest. Observations included degree of defoliation; condition, drop and soluble solids of the fruit: vigor and winter hardiness of the canes.

Considerable variation was found in degree of defoliation and berry drop from the use of different chemicals. Magnesium chlorate and sodium chlorate were the most promising of the defoliants tried. The amount of berry drop paralleled the degree of defoliation. The chemicals as used had no significant effects on the soluble solids of the fruit. Endothal did cause off-flavor of the fruit. No material, except Diquat, had any visible effect on vine growth or susceptibility of the canes to winter injury.

Even though chemical defoliation of grapes appears promising, development will be dependent upon basic knowledge of environmental and physiological factors associated with leaf and fruit abscission.

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THE RESPONSE OF FLORICULTURAL CROPS TO VARIOUS GROWTH REGULATORS

I. Effect of (2 Chloroethyl)trimethylammonium Chloride on Poinsettia, (*Euphorbia Pulcherrima*, Willd.)

By RICHARD S. LINDSTROM

Department of Horticulture

THE USE OF QUARTERNARY AMMONIUM compounds as plant growth substances for regulating the height of floricultural crops has recently been reported by Lindstrom and Tolbert in 1960[1] and the U. S. Department of Agriculture in 1961.[2] Some effects of (2-bromoethyl)-trimethylammonium bromide (AMAB) on the growth of poinsettia have already been reported by Lindstrom and Tolbert in 1960. Growth could be inhibited most effectively when the chemicals were applied as a soil drench or when they were mixed directly into the soil before planting.

This paper reports detailed results of the effects of (2-chloroethyl)trimethylammonium chloride (CCC)[3] on poinsettia. The results confirm and extend the information reported earlier for AMAB and BCB.

TRIAL 1

Methods and Materials

Poinsettia cuttings (var. Barbara Ecke Supreme) were planted in a propagation bench on May 25, 1960. On June 21, 1960, rooted

[1]Lindstrom, R. S. and N. E. Tolbert (1960). (2-chloroethyl)trimethylammonium chloride and related compounds as plant growth substances. IV. Effect on chrysanthemums and poinsettias. Mich. Agr. Expt. Sta. Quart. Bul. 42: 917-928.

[2]Dwarfing plants with chemicals. ARS Special Report 22-65, Agricultural Research Service, U.S.D.A. p. 14, 1961.

[3]Supplied as a 50% aqueous solution of (2-choroethyl)trimethylammonium chloride by the American Cyanamid Company, Stamford, Conn.

ARTICLE 43–87

cuttings were potted in 3-inch pots and were repotted into 4-inch pots on July 13, 1960. The soil in which the plants were growing was drenched with 100 ml. of CCC at 10^{-2}M. or 5 x 10^{-2}M. per 4-inch pot on July 20, 1960. The plants were again repotted into a 6-inch pot (1 plant per pot) on August 16, 1960, and three groupings were arranged: 1) plants chemically treated while in the 4-inch pot, but not treated after repotting in a 6-inch pot, 2) plants chemically treated once in a 4-inch pot and once in a 6-inch pot, and 3) plants chemically treated once in a 4-inch pot and treated twice in a 6-inch pot. The chemical was applied as a soil drench to the 6-inch pots the same day that they were repotted (August 16, 1960) with 100 ml. of CCC at the above concentrations. Those plants treated twice in a 6-inch pot were treated the second time on September 15, 1960.

Results

Reduction in growth of poinsettia was apparent within 1 to 2 weeks after the first chemical treatment, irrespective of concentration used. With no re-treatment after repotting into a 6-inch pot, rapid vegetative growth was initiated, as shown by the greater length of internodes in plants treated only once compared with those treated twice (Fig. 1).

As growth continued, the suppressing effect of CCC from the second application gradually lessened. At the final measurement, plants treated with one and two applications of 5 x 10^{-2}M. CCC were 34 to 38 cm. taller than the plants treated three times (Table 1). Only plants which received three treatments of CCC at 5 x 10^{-2}M. had internodes which remained consistently short throughout the growth of the plant (Fig. 2). Differences in growth between plants treated with CCC at 10^{-2}M. and 5 x 10^{-2}M. are noted (Table 1).

Leaves on CCC-treated plants were a darker green in comparison to the control plants. Some abscission of the lower leaves occurred with all plants, but it was not excessive.

The appearance of the bracts and time of flowering on treated and control plants were similar. However, all plants propagated May 25 produced bracts which were well in advance of those plants propagated from cuttings several months later. Anthesis in the earlier propagated material was approximately November 25, 1960.

Fig. 1. Effect of CCC on the growth of poinsettia. Plants were propagated May 25 and first treated at 5 x 10^{-2}M. on July 20, 1960. The chemical was applied the second time on August 16, 1960, for those plants requiring a second treatment. Treatments are described from left to right: 1) control, 2) treated at 5 x 10^{-2}M. on July 20, and 3) treated at 5 x 10^{-2}M. on July 20 and August 16, 1960. Plant on right illustrates continued shortening of internodes when chemical is applied the second time. Photographed September 16, 1960.

TRIAL 2

Methods and Materials

Poinsettia cuttings (var. Barbara Ecke Supreme) were placed in the propagation bench on August 2, 1960. After rooting, they were potted in 3-inch pots August 30. The plants were then "panned" (3 plants per pot) in 6-inch pots on September 15. Plants were next divided into two groups: Trial 2a)—those in which CCC was applied September 22 as a soil drench at 100, 200, or 300 ml. per pot at concentrations of either 10^{-2}M. or 5 x 10^{-2}M., and trial 2b)—those in which CCC was applied October 4 as a soil drench at 100, 200, 250 or 300 ml. per pot at either 10^{-2}M. or 5 x 10^{-2}M. Plants in trial 2a were watered liberally at all times, while those in trial 2b were watered less frequently and held considerably drier. All plants were grown under natural photoperiods.

Results: Trial 2a

Visible reduction of growth was observed 1 to 2 weeks after chemical treatment. Plants treated at 10^{-2}M. and 5 x 10^{-2}M. grew at similar rates for the first 4 to 5 weeks, after which plants treated at 10^{-2}M. began growing at an accelerated rate. Plants treated at

Fig. 2. Effect of CCC on the growth of poinsettia. Plants were propagated May 25 and first treated on July 20, 1960. Part of the plants received a second treatment on August 16 and the remainder received a third treatment on September 15, 1960. Treatments are described from left to right: 1) control, 2) treated July 20 and August 16 at 5 x 10^{-2} M., and 3) treated on July 20, August 16, and September 15 at 5 x 10^{-2}M. When growing period is extended, three or more chemical applications are necessary to insure continued dwarfing. Photographed December 9, 1960.

TABLE 1—Effect of CCC (applied one, two, or three times) on the height of poinsettia plants propagated May 25 and treated July 20, 1960(a)

Treatment	Concentration (molar)	Number of applications	Height (cm.)
Control (no treatment)			161
CCC	10^{-2}	1	137
		2	139
		3	111
	5×10^{-2}	1	97
		2	93
		3	59
L.S.D. 5 percent			12
1 percent			16

(a) Part of the plants received a second treatment on August 16 and the remainder received a third treatment on September 15, 1960. Measurements were recorded December 1, 1960.

5×10^{-2}M. grew very slowly for approximately 7 to 8 weeks before reverting to a normal rate of vegetative extension. Non-treated plants were 16 to 34 cm. taller than those which were chemically treated (Table 2).

The bract size on plants treated at 10^{-2} M. was as large as on the non-treated control plants, but there was a significant reduction at 5×10^{-2}M. In this instance, leaves on treated plants were a darker

TABLE 2—Effect of CCC (applied in amounts of 100, 200, and 300 ml.) on the height of poinsettia plants propagated August 2 and treated September 22, 1960(a)

Treatment	Concentration (molar)	Amount of chemical applied (ml.)	Height (cm.)
Control			70
CCC	10^{-2}	100	54
		200	54
		300	49
	5×10^{-2}	100	39
		200	40
		300	36
L.S.D. 5 percent			8
1 percent			10

(a) Plants were uniform at time of treating and only measured on December 4, 1960. Plants supplied with adequate moisture.

green than on the controls and remained on the stems to the soil line in both control and treated plants. Flower development on all plants was comparable.

Results: Trial 2b

In this trial, in which the plants were grown with a shortage of water, there was a marked difference in the size of the plant and the size and appearance of the bracts when various amounts of the chemical were used at either concentration. Plants treated at 10^{-2}M. increased in height from 13 to 15 cm. after treatment, while at 5 x 10^{-2}M. the plants grew only 5 to 12 cm. During the same interval, non-treated plants elongated 44 cm. (Table 3).

TABLE 3—Effect of CCC (applied in four different amounts) on the height of poinsettia plants propagated August 2 and treated October 4, 1960(a)

Treatment	Concentration (molar)	Amount of chemical applied (ml.)	Increase in height (cm.)
Control			44
CCC	10^{-2}	100	13
		200	15
		250	14
		300	13
	5 x 10^{-2}	100	12
		200	9
		250	7
		300	5
L.S.D. 5 percent			4
1 percent			5

(a) First measurement was recorded October 4, and the last measurement was recorded December 5, 1960. Plants were held dry.

Bract size was noticeably smaller and somewhat delayed when 200, 250, or 300 ml. solutions at 5 x 10^{-2}M. were applied. Bracts also appeared "crinkled" or "ruffled". Even when 100 ml. of CCC was applied at 5 x 10^{-2}M., some crinkling persisted and bracts were still somewhat smaller than control plants (Fig. 3). The size and appearance of bracts on plants treated at 10^{-2}M. were very satisfactory (Fig. 4). Only the bracts of one out of 18 treated with 300 ml. of 10^{-2}M. showed signs of crinkling.

Leaf abscission on the lower stem parts was common on plants that were treated with 300 ml. of CCC at 5 x 10^{-2}M. (Fig. 3). The

Fig. 3. Effect of CCC on the growth and appearance of bracts of poinsettia. Plants were propagated August 2 and treated October 4, 1960. Treatments are described from left to right: 1) control, 2) treated with 300 ml. of CCC at 5 x 10^{-4}M., and 3) treated with 100ml. of CCC at 5 x 10^{-4}M. Crinkled appearance of bracts are apparent on center plant. Photographed December 16, 1960.

Fig. 4. Effect of CCC on the growth and appearance of bracts of poinsettia. Plants were propagated August 2 and treated October 4, 1960. Treatments are described from left to right: 1) control, 2) treated with 250 ml. of CCC at 10^{-2}M. and 3) treated with 100 ml. of CCC at 10^{-2}M. Excellent control of growth and bract development is illustrated on center plant. Photographed December 16, 1960.

dropping of the lower foliage was not observed, however, with any treatment at either 10^{-2}M. or with 100, 200, or 250 ml. at 5 x 10^{-2}M.

DISCUSSION

Heights of plants treated once (July 20) or twice (July 20 and August 16, 1960), but not retreated the third time, were not retarded as much as plants treated three times (Table 1). It has been suggested (Lindstrom and Tolbert, 1960) that an accumulation of endogenous gibberellin may overcome the effects of the dwarfing compound. However, repeated treatments after repotting resulted in continued dwarfing of the plant. This would indicate that the effect of the CCC was negated when 1) the roots grew into non-treated soil, or that 2) CCC did not persist and the soil should be retreated every 4 to 8 weeks for a continuation of the dwarfing effect. Perhaps a fourth application of CCC applied in October for plants propagated on May 25 would have still further reduced their height; however, it is difficult to predict what effect the fourth treatment would have had on bract formation.

Flowering occurred well in advance of Christmas on the very early (May 25) propagated plants. In the greenhouse production of the poinsettia, because of the photoperiodic response of this plant, it is suggested that a long photoperiod should be given (until October 5 or October 10) so that flowering might occur just before the Christmas holiday season.

In these experiments, plants propagated May 25 and August 2 were exposed to the natural photoperiod. Those propagated August 2 flowered just before Christmas while those propagated in May flowered a month earlier. With the May 25 propagated plants, it is suggested that internal or external conditions (other than CCC), possibly triggered by the maturity of the plant, resulted in earlier flowering of the poinsettia.

Plants treated September 22, 1960, (trial 2a) were taller than similarly propagated plants treated October 4, 1960 (trial 2b). As noted earlier in this paper, plants in trial 2a were liberally watered at all times while water was withheld from plants in trial 2b. With a better understanding of the limitations and advantages of chemically treating poinsettias, a plant of the prescribed height and quality may be produced without necessitating the with-holding of water.

This will be accomplished by repeated applications of CCC depending upon concentration and time of propagation.

Plants treated on October 4, 1960, with CCC at 10^{-2}M. produced, for the most part, bracts which were as acceptable as those on the control plants. The problem, therefore, involves three considerations: 1) using a concentration of the chemical which will effectively reduce the height of the plant, 2) using the proper concentration of the chemical in order to insure proper bract development, and 3) proper timing of repeated treatments to insure continued dwarfing as well as good bract development. With May or June propagated poinsettias, repeated treatments of CCC at 5 x 10^{-2}M. will be needed to insure proper control of height. With cuttings propagated from July 15 to August 15, desirable plants could be obtained by applying CCC at 10^{-2}M., possibly at monthly intervals up to October 15.

SUMMARY

Poinsettia plants propagated May 25 and August 2, 1960, were chemically treated (soil drench) with 10^{-2}M. or 5 x 10^{-2}M. of (2-chloroethyl)trimethylammonium chloride (CCC).

May 25 propagated plants were treated once, twice or three times and the height of the plant and bract development was observed. Treated plants were significantly dwarfed when 100 ml. of CCC at 5 x 10^{-2}M. per plant was applied three times at approximately monthly intervals. Bract development on treated plants was similar to controls.

August 2 propagated plants were divided into two groups: 1) plants chemically treated with 100, 200 or 300 ml. of CCC at 10^{-2}M. or 5 x 10^{-2}M. on September 22 and watered liberally, and 2) plants chemically treated with similar amounts of CCC at 10^{-2}M. or 5 x 10^{-2}M. on October 4 and watered less frequently.

Superior dwarfing was observed in the plants treated October 4. Bracts of plants treated at 5 x 10^{-2}M. were usually "crinkled", while plants treated at 10^{-2}M. appeared similar to controls. Most effective control of height and bract development was observed on plants treated with CCC on October 4 at 10^{-2}M.

ACKNOWLEDGMENT

The author is indebted to Drs. S. H. Wittwer and N. E. Tolbert for critically reviewing this paper.

JOURNAL ARTICLE ABSTRACTS

Evaluation of Neomycin Sulfate in the Treatment of Bovine Mastitis

DRURY, A. R.

Vet. Med. 47(10): 1952. (Journal Article 1354 from the Michigan Agricultural Experiment Station)

No reports existed indicating the effective levels of neomycin sulfate needed to inhibit mastitis causing organisms prior to this work so in vitro studies were carried out to furnish this information. Next, the effect of the drug in the udder was determined by response of leucocyte shedding, chloride content, resazurin class, pH, and strip cup examination of the milk. Retention in the udder was found to be 72 hours when an aqueous solution was infused. Intra-muscular injections of 2 gm. produced blood levels detectable for 9 hours. After this preliminary work, the drug was deemed suitable to treat cows in the field. The results in treating 405 cases of mastitis indicate this drug to be effective against infections caused by streptococci, staphylococci, coliforms and a yeast. Neomycin was also of value in eight of 14 Pseudomonas infections.

The Treatment of Bovine Mastitis with Aureomycin

DRURY, A. R.

M.S.C. Vet. 13(2): 104-107. 1953. (Journal Article 1424 from the Michigan Agricultural Experiment Station)

This article reports on the treatment and follow-up of 48 cases of mastitis treated with aureomycin. The irritation to the udder was determined when 100mg., 200mg., and 400mg doses were infused. Sixteen of 22 cows infected with staphylococcus recovered when treated with aureomycin. Six did not and of these two died and the other four were sold for slaughter after acute symptoms subsided. Twenty-three cows with streptococcus infection were treated with aureomycin; 17 responded and six did not. These six were treated with 100,000 units of penicillin and four responded, leaving two still shedding organisms. The remaining cases were two coliform that responded and one nonspecific mastitis. A detailed case history of streptococcus agalactiae infected cow is reported pointing out the fact that clinical recovery is not sufficient, and laboratory follow-up is necessary.

Some Practical and Fundamental Aspects of Weed-Control in Gladiolus

CARLSON, R. F.

The Gladiolus. 28th Annual Edition: 83-86. 1953. (Journal Article 1501 from the Michigan Agricultural Experiment Station)

The basic aspects toward weed-free gladiolus plantings are: thorough preparation of the soil, selection of the proper pre-emergence herbicide, and application of this chmical at the recommended rate when the soil surface is moist.

Furthermore, the interval between planting and the first herbicide application should be about 10 to 12 days to allow the maximum number of weed seeds to germinate and to make them more susceptible to the chemical.

Sesone (Crag Herbicide 1) was the most effective weed control chemical out of several tested. This material was effective both under pre and post-emergence application conditions. Corms were more resistant to the chemicals than were the cormels.

Estimated Dietary Intake, Urinary Excretion and Blood Vitamin C in Women of Different Ages

Roderuck, Charlotte; Lida Burrill; Lois Jackson Campbell; Betty Einbecker Brakke; Marian Tolbert Childs; Ruth Leverton; Marilyn Chaloupka; Emil H. Jebe and Pearl P. Swanson

Jour. of Nutr. 66(1): 15-27. 1958. (Journal Article 1824 from the Michigan Agricultural Experiment Station)

The nutritional status of 569 women (68 of whom were studied twice) from 5 locations in the North Central states has been examined with respect to vitamin C. Whole blood, plasma or serum concentrations of vitamin C were related to the estimated dietary intake. Mean blood values for the state samples varied from 0.76–0.463 to 1.20–0.553 mg. of vitamin C per 100 ml.

An Experimental Infectious Bronchitis Virus Vaccine Inactivated with Beta-propiolactone

Christian, R. T. and Walter Mack

Poultry Sci. 36: 1177-1181. 1957. (Journal Article 2071 from the Michigan Agricultural Experiment Station)

Studies on a beta-propiolactone altered infectious bronchitis virus vaccine. Robert T. Christian and Walter N. Mack, Dept of Microbiology and Public Health, Michigan State University, East Lansing.

Egg-propagated IBV (infectious bronchitis virus) was treated with 0.025 percent BPL (beta propiolactone) at 37° C. for 5, 10, 20, 40, 60, 80 and 120 minutes. Chickens were vaccinated intramuscularly with 0.5, 1, or 2 ml. of the experimental vaccine. No vaccine reaction was observed. Nineteen days after vaccination, the vaccinated birds and the unvaccinated controls were challenged by the tracheal route with IBV 10^{-5} LD^{50} embryo infective dose. Nearly twice as many unvaccinated controls were susceptible to the challenge as the 1 and 2 ml. vaccinates. These data, when analyzed statistically, indicate that the difference between birds designated positive in the control group (14/33) and those designated positive in the 1 ml. vaccinate group were significant below the 1 percent level. When the control group was compared to the 1 and 2 ml. vaccinates (12/70), the difference was significant below the 2 percent level. The sera collected from the vaccinated birds indicated a slight rise in serum neutralizing antibodies.

A Method for Measuring the Oxygen Consumption of Fish

FROMM, P. O.

Progressive Fish-Culturist 20: 137-139. 1958. (Journal Article 2081 from the Michigan Agricultural Experiment Station)

The oxygen consumption of individual fish was measured while they were confined in separate tubes of a constant flow apparatus. Water was pumped from an aquarium into a constant pressure chamber and from there it flowed via gravity through a bubble trap, the fish chamber, and then back into the aquarium. The rate of flow through the fish chamber was regulated by an adjustable pinch cock. A semi-micro modification of the Winkler method was used to measure the dissolved oxygen content of the water. The oxygen consumption of the fish was calculated from measurements of the difference in the dissolved oxygen content of the water entering and leaving the fish chamber and the rate of flow through the chamber. Data was presented to show how the apparatus was used in a study of the effect of chromium on the oxygen consumption of *Micropterus salmoides.*

Antibiotic Sensitivity Tests of Mastitis-Causing Bacteria

DRURY, A. R.

Vet. Med. 53: 354. 1958 (Journal Article 2138 from the Michigan Agricultural Experiment Station)

The results of 100 consecutive sensitivity tests of causal organisms isolated from milk of cows with mastitis are reported. There is a breakdown of the response of streptococcus and staphylococcus species to several antibiotics. Penicillin and oxytetracycline showed ability to inhibit organisms in vitro on 76% of tests for all organisms. Following closely were chlortetracycline at 75%, streptomaycetin at 74%.

Penicillin, as a single antibiotic, was able to inhibit 92% of the streptococcus and 88% of the staphylococcus in vitro. However, Special Formula 17900 was superior in all categories to any single antibiotic.

Chemical Induction of Male Sterility in Inbred Maize by Use of Gibberellins

NELSON, PAUL M. AND E. C. ROSSMAN

Science 127(3313): 1500-1501. 1958. (Journal Article 2185 from the Michigan Agricultural Experiment Station)

Foliar sprays of 500 to 2500 p.p.m. of gibberellin induced male sterility in two inbred lines, R_{53} and Oh_{51}. Complete male sterility occured in two treatments on Oh_{51} and 87% complete sterility occurred in two treatments on R_{53}.

Induction of male sterility depended upon concentration of gibberellin, directing the spray into the leaf whorl, and the stage of plant development. The estimated effect range of gibberellin was 5 to 35 milligrams per plant. The critical stage occurred when plants had developed about 1 inch of immature tassel inflorescence.

Silks were functional and there were no "carry-over" effects on pollen production in the succeeding generations. Effects on flowering time and mature plant height were small and inconsistent.

Further investigations are needed to determine the reliability of this chemical (gibberellin) "sterilization" and its application in the production of hybrid seed corn.

Measurement of Some Physiological Parameters in Rainbow Trout (Salmo Gairdnerii)

Schiffman, R. H. and P. O. Fromm

Canadian Jour. of Zoology. 37: 25-32. 1959. (Journal Article 2241 from the Michigan Agricultural Experiment Station)

Data on physiological parameters such as hematocrit, hemoglobin, erythrocyte count and size, organ weights, body water weight, plasma, and blood volume are given for hatchery raised *Salmo gairdnerii*. Methods for obtaining the above data, using fingerlings varying in weight from 9 to 29 grams, are discussed. Mean values reported are as follows: Hematocrit 31.8; Hemoglobin 6.51 gm 100 ml blood; R.B.C. count 1.11 million mm^3; R.B.C. length 14.67 microns. Kidney, liver and spleen weights, as well as total body water, plasma and blood volumes were found to be statistically valid factors of body weight. Straight-line regression equations are given for each. A comparison of these data with recent summaries of similar data is given and possible reasons for discrepancies are discussed.

Chromium-Induced Changes in the Blood of Rainbow Trout, Salmo Gairdnerii

Schiffman, R. H. and P. O. Fromm

Sewage and Industrial Wastes. 31(2): 205-211. 1959. (Journal Article 2242 from the Michigan Agricultural Experiment Station)

The 24-hour median tolerance limit of trout to K_2CrO_4 in a concentration expressed in mg. 1 of Cr. is 100. The hematocrits of both splenectomized and intact fish exposed to 20 mg. 1 of Cr. were significantly higher than control fish exposed in clean tap water. Exposure of fish to as low as 2 to 4 mg. 1 of Cr. was found to raise the hematocrit to its maximum value. This rise in hematocrit can be accounted for by an increase in cell number, cell volume, and a probable, but unproven, decrease in plasma volume. The presence of the spleen revealed it to have no influence on the rise in hematocrit under chromium stress; in fact, the data indicate the spleen may act weakly as a buffer against sudden hemoconcentration. The potential influence of the potassium ion in the K_2CrO_4 on the experimental results is discussed.

Plant Availability of Fertilizer Phosphorous as Affected by Solubility, Particle Size, and Placement of Fertilizers

Lawton, Kirk

Procchio del II Simposio Internazionale di Agrochimica (Isola d'Elba, Italie): 329-341. 1958. (Journal Article 2294 from the Michigan Agricultural Experiment Station)

Laboratory, greenhouse, and field studies with P^{32} labelled fertilizers indicate that plant availability of fertilizer phosphorus is dependent on solubility, particle size, and placement of fertilizer. When pulverant fertilizer was well mixed with soil, the percent of phosphorus in a water soluble state had little effect in controlling growth and absorption of fertilizer phosphorus by plants.

However, when granular fertilizer was mixed with soil or when pulverant or granular fertilizers were applied in rows, crop growth and the uptake of fertilizer phosphorus was found to be closely correlated with the percent of phosphorus in the fertilizer soluble in water. For maximum production of phosphate responsive crops, fertilizers applied in bands and granular fertilizer disced into the soil should contain not less than 40 to 50 percent of their phosphorus in a water soluble form.

Hemodynamic Changes Associated with Aging in the Broad Breasted Bronze Turkey

RINGER, ROBERT K. AND KENNETH ROOD

Poultry Sci. 38: 395-397. 1959. (Journal Article 2296 from the Michigan Agricultural Experiment Station)

Broad Breasted Bronze poults were hatched every 2 weeks for eight consecutive hatches. Direct blood pressure measurements were taken from males and females, starting when the youngest group was 8 weeks of age and the oldest 22 weeks old.

The systolic and diastolic blood pressure, and pulse pressure of the 20- to 22-week-old male is significantly higher than the female, while the heart beat rate is not significantly different. Systolic pressure of the 22-week-old male turkey (296.7) increased about 50 percent from the 8-week-old male turkey (197.8). The systolic pressure in the female rose from 189.3 to 257.3 for the same ages, representing a change of 36 percent. Discussed is the possibility that blood pressure changes throughout aging may be associated with aortic rupture in this breed.

An Activity Cage and Recorder for Domestic Fowl

RATNER, S. C. AND R. K. RINGER

Animal Behaviour. 7: 245-247. 1959. (Journal Article 2314 from the Michigan Agricultural Experiment Station)

An activity cage and recorder were constructed for use with domestic fowl and small animals. The device consisted of a square cage mounted on a centre post, pins and microswitches. Two magnetic counters, activated by the microswitches, served as recorders. Three independent sources of observation, (a) simultaneous visual check of birds' movements and counter activations, (b) correlation between visual records and independent counter recordings (rank order correlation equals 0.90), and (c) activity records with increasing doses of tranquilizers, gave reason to believe that this method of recording activity was highly reliable.

Chemoprophylaxis of Poliomyelitis in Mice through the Administration of plant Extracts

COCHRAN, KENNETH W. AND E. H. LUCAS

Antibiotics Annual 1958-1959: 104-109 (Journal Article 2328 from the Michigan Agricultural Experiment Station)

The objective of this investigation was to determine whether different principles possessing known biological action (such as extracts of holobasidio-

mycetes with anticancer activity) could also have antiviral activity. Poliomyelitis was used as the test organism. Eventually, the scope was expanded to include a variety of green plant materials.

Poliomyelitis was produced in young (approximately 10 g) Webster mice by the intraperitoneal inoculation of the MEF, strain of type II poliomyelitis virus, using a challenge of approximately 10 ID_{50}. These animals were checked for paralysis regularly for 21 days.

Mice were partially protected from infection with MEF_1 poliomyelitis by treatment with several plant extracts. Active extracts were obtained from two strains of *Calvatia gigantea* and several other species of higher fungi; from several *Cattleya* hybrids and some other species of *Orchidaceae;* from *Hypericum perforatum* and *H. prolificum;* and from species of the following genera: *Allium, Kalmia, Maclura, Phellodendron, Medicago,* and *Ribes.*

Absorption and Distribution of Foliar Applied Mineral Nutrients as Determined with Radioisotopes

BUKOVAC, M. J. AND S. H. WITTWER

Plant Analysis and Fertilizer Problems. 8: 215-230. 1961. (Journal Article 2490 from the Michigan Agricultural Experiment Station)

Of techniques utilized for studying foliar absorption of labeled mineral nutrients, the leaf washing procedure offered the most promise for accurately distinguishing between the absorbed and nonabsorbed nutrients following application to leaf surfaces, for minimizing errors encountered with some nutrients that are not readily translocated, and for accurately establishing absorption rates. Mg^{28}, Ca^{45}, Fe^{55-59} and Zn^{65} were readily absorbed by the bean leaf, but negligible transport occurs therefrom. Other isotopes, such as Na^{22}, P^{32}, S^{35}, and Cl^{36}, were readiy absorbed and transported from the site of uptake, and considerable foliar absorbed Na^{22} was accumulated in the stems. Maleic hydrazide reduced the uptake of P^{32}, and gibberellin A_3 its subsequent transport to the roots. Foliar absorbed calcium[45] transport out of leaves was induced by 2, 3, 5-triiodobenzoic acid, and greater mobility of Zn^{65} followed treatment of plants with α-naphthaleneacetic acid. Foliar sprays of P^{32} labeled ortho-phosphoric acid applied to tree fruits and several vegetable crops supplied 8 to 15 percent of the total phosphorus utilized in the reproductive organs.

Lysis of Mycelium of Plant Pathogenic Fungi by Natural Soil

LOCKWOOD, JOHN L.

Phytopathology. 50(11): 787-789. 1960. (Journal Article 2498 from the Michigan Agricultural Experiment Station)

Natural soil lysed mycelium of 20 permanent, temporary, and non-soil-borne plant pathogenic fungi growing on agar media. Most temporary and permanent soil fungi were more resistant to lysis than non-soil fungi, but the two groups of soil fungi could not be differentiated on this basis. Killed cultures of temporary and permanent soil fungi on peptone agar generally were more readily lysed than living cultures; on Czapek's agar, lysis of living and killed cultures was equal. Some fungi lysed more completely on peptone than on Czapek's agar. There was no relation between the root-infecting habit and resistance to lysis among the soil fungi. The fungi were grouped into seven classes based on the

extent of lysis of living and killed mycelium in peptone and Czapek's agar. The lysis patterns were consistent with the interpretation that antibiotics in soil cause autolysis and/or death of mycelium, and externally produced cell wall decomposing enzymes lyse the moribund or killed mycelium.

Observations on the Absorption of Glucose into the Portal Vein

FRIES, G. F. AND G. H. CONNER

Jour. of Dairy Sci. 43(12): 1851-1852. 1960. (Journal Article 2522 from the Michigan Agricultural Experiment Station)

Blood glucose levels of the portal vein and carotid artery of a 500-pound calf were determined at regular intervals for 12 hours after feeding. With a corn and alfalfa hay ration, the glucose level average 5.4 mg. % higher in the portal vein than in the carotid artery. With a corn and timothy hay ration, the average difference was -1.7 mg. %. The results indicate that under some conditions, glucose may be an important end-product of ruminant digestion.

Heat Inactivation of Substances in Crude Cottonseed Oil Causing Pink Whites and Large Discolored Yolks in Stored Eggs

EVANS, ROBERT JOHN; SELMA L. BANDEMER AND J. A. DAVIDSON

Poultry Sci. 39(6): 1478-1483. 1960. (Journal Article 2582 from the Michigan Agricultural Experiment Station)

S. C. White Leghorn pullets were fed rations containing 2.5% of crude cottonseed oil. Groups of pullets were fed the unheated crude cottonseed oil or the oil heated for 1, 2, 4, or 8 hours at 100 to 240° C. Eggs produced by these pullets were stored 6 to 12 months and then observed for pink white and salmon yolk discoloration. Portions of the various crude cottonseed oils were tested by means of the Halphen reaction for cyclopropene ring containing fatty acids. Stored eggs from hens fed crude cottonseed oil developed pink whites and large salmon or large brown thick translucent curdled yolks. Crude cottonseed oil gave a strong Halphen test. Crude cottonseed oil, heated at 150° C. for 4 hours or 200° C. for 1 hour, no longer gave the Halphen test but still produced egg discoloration. No egg discoloration was observed when crude cottonseed oils heated at 200° C. for 8 hours or at 240° C. for 1 hour were fed. The cyclopropene ring, as evidenced by a positive Halphen reaction, may not be necessary for the production of pink white and large salmon yolk discolorations of stored eggs.

The Influence of Multiple Dozen Cartons, Brand and Display on Egg Sales

HOYT, C. C. AND L. E. DAWSON

Poultry Sci. 39(60): 1453-1459. 1960. (Journal Article 2586 from the Michigan Agricultural Experiment Station)

Seventy-four thousand dozen eggs were merchandized in four Lansing supermarkets during a 21-week period. Special egg display cabinets were placed in similar locations within each store and were used throughout the study. Supplemental display area, single and multiple unit cartons, price advantage for multiple unit purchases, and brands were important variables of the study. Consumer acceptance was measured by egg purchases.

Significantly more eggs were purchased in multiple dozen cartons than in single dozen cartons when priced 1 and ½ cents less per dozen. The volume of eggs purchased from the special display cases and total eggs purchased in all stores decreased when the 2-dozen packages were replaced by single dozen units, even though the price differential remained for purchases of 2 dozen at a time. During the study, one supplier changed brands and sales remained essentially the same.

The Dynamic Character of Potassium Release and Fixation

Mortland, M. M.

Soil Sci. 91(1): 11-13. 1961 (Journal Article 2587 from the Michigan Agricultural Experiment Station)

The dynamic nature of potassium release and fixation is illustated in an experiment where clays from five Michigan soils are mixed with equivalent weights of biotite for a period of 21 days. During this time, the soil clays fixed potassium which the biotite released. The rate of fixation was inversely related to the initial potassium content of the clay. The results are interpreted in terms of a diffusion process.

Effect of Compaction, Depth of Planting, and Soil Moisture Tension on Seedling Emergence of Alfalfa

Triplett, Glover B., Jr. and Milo B. Tesar

Agron. Jour. 52: 681-684. 1960. (Journal Article 2597 from the Michigan Agricultural Experiment Station)

Alfalfa seeds were planted in the field at four depths: 0, ¼, ½, and 1 inch, and four compactions, 0, 3, 6 and 12 p.s.i. on two soil types, a silt loam and a sandy loam. Moisture was controlled by irrigation and sheltering from rain. With no irrigation after planting, emergence was increased by increasing compaction and depth, the greastest emergence being at ½ to 1-inch depth and 6 to 12 p.s.i. compaction. With irrigation after planting, emergence was highest from the ½-inch depth with little influence from compaction. Emergence of seeds planted on the surface increased with increasing compaction in all cases. Emergence was correlated with soil moisture tension in the surface inch of soil 1 day after planting.

Factors Affecting Zoospore Production by Aphanomyces Euteiches

Llanos M., Carmen and J. L. Lockwood

Phytopathology 50(11): 826-830. 1960. (Journal Article 2599 from the Michigan Agricultural Experiment Station)

Cultures of *Aphanomyces euteiches* isolate 50, grown for 5 days in maltose-peptone broth, produced more zoospores when the medium was replaced with tap water for ½ hours and followed by distilled water, than with other water combinations. Tap water alone produced fewest zoospores. When 30 or 50 ml. of distilled replacement water were used, more zoospores were obtained with 5-day old cultures than with cultures 3, 7, 9, or 11 days old. When 20 ml. of distilled replacement water was used, highest concentrations were obtained

with cultures 3 days old. Largest numbers of zoospores of isolates, 50, 72, and 103, were produced when temperature of the distilled replacement water was 24° C. The optimum culture temperatures range for zoospore production of isolate 50 was 20-28°. Vegetative growth was maximum at 28°. Under optimum conditions, 5-day old cultures of isolates 50, 72, and 103 usually produced 2-3 x 10^5 zoospores per ml. of distilled replacement water. Aeration of distilled replacement water containing mycelium increased zoospore production by isolate 50 from 2-4 times, and by isolate 102—normally a poor zoospore producer—6 or more times. Presence or absence of light had no effect on zoospore production by isolate 50.

A Chitin Medium for Isolation, Growth, and Maintenance of Actinomycetes

LINGAPPA, YAMUNA AND JOHN L. LOCKWOOD

Nature. 189 (4759): 158-159. 1961. (Journal Article 2608 from the Michigan Agricultural Experiment Station)

Media currently used for isolation of actinomycetes from soil are non-specific and permit growth of bacteria and fungi as well as actinomycetes. Additives to these media, for the purpose of suppressing contaminants, are only partly successful. A mineral medium employing colloidal chitin as the sole source of carbon and nitrogen gave more actinomycete colonies and markedly fewer bacterial and fungal colonies than did conventional media. More growth of three species of streptomyces was obtained in chitin-mineral liquid medium than in conventional media. Chitin-mineral agar slants supported excellent growth and sporulation of actinomycetes.

Chemical Control of the Eastern Spruce Gall Aphid with Observations on Host Preference and Population Increase

BUTCHER, J. W. AND DEAN L. HAYNES

Jour. of Econ. Enty. 53(6): 979-982. 1960. (Journal Article 2619 from the Michigan Agricultural Experiment Station)

Field insecticide studies demonstrate that Lindane (1 lb. actual toxicant per 100 gallons of water) will give good control of Eastern spruce gall aphid when applied between the time of last freeze and start of terminal shoot elongation. Sevin (2 lbs.) was less effective, (while dimethoate (2 lbs.), malathion (1 lb.), and Phosdrin (1 lb.) gave little or no control. Statistical analyses of infestations over a 2-year period show (1) a 15% greater incidence of attack on white as opposed to Norway spruce; (2) a 6% increase in over-all infestation from 1958 to 1959; (3) a strong tendency for infestations to recur on previously infested trees. This suggests that by harvesting infested trees, a grower could reduce the infestation in a given planting, if such a program were initiated before the percentage of attacked trees was too high. Finally, the view that certain trees are resistant to aphid attack is questioned, using as a basis the tendency of this insect to reinfest previously infested trees. It is reasoned that, even though new and previously uninfested trees appear to be randomly attacked each year, the rate of spread is so slow that one-fifth of the trees in the study area are expected to remain uninfested for 5 consecutive years, due to insect behaviour alone.

Absorption and Distrbution of Sodium, Phosphorus, Chlorine, Calcium and Zinc in Some Selected Woody Ornamentals

BUKOVAC, MARTIN J. AND HAROLD DAVIDSON

Biologia Plantarum (PRAHA). 3(1): 39-46. 1961. (Journal Article 2621 from the Michigan Agricultural Experiment Station)

The foliar absorption and subsequent distribution of sodium, chlorine, calcium, and zinc in 1-year-old rooted cuttings of *Forsythia intermedia*, Zabel, and root absorption of phosphorus by *Taxus cuspidata* Sieb. and Zucc., was established. The percentage of the applied nutrient translocated out of the treated leaf was used as a criterion of mobility. Sodium and chlorine were found mobile, calcium immobile, and zinc slightly mobile. Less than 1 percent of the phosphorus applied to the shoots of both actively growing and semi-dormant *Taxus cuspidata* plants was recovered in the roots after a 12 day absorption-transport period. Six percent of the total phosphorus recovered in the tops was derived from a single soil application of a water soluble fertilizer (10-52-17) after 12 days, although, less than 0.5 percent of the applied fertilizer phosphorus was absorbed.

In Vitro I^{131} Uptake by Salivary Glands, Stomach and Placenta

MAQSOOD, M. AND E. P. REINEKE

The Amer. Jour. of Physiology. 199(6): 1045-1047. 1960. (Journal Article 2639 from the Michigan Agricultural Experiment Station)

Slices of various tissues of the rat were incubated at 37° C. for 6 hours in 2 ml. of medium containing 0.3 μc carrier-free I^{131}. I^{131} concentration significantly above that of the medium, and of boiled tissues, was observed in salivary glands and stomach, but not in liver or placenta. I^{131} uptake by parotid was significantly higher than that of submaxillary and sublingual tissues. Uptake by tissues from the cardiac portion of the stomach was significantly greater than in those from the pyloric portion. Concentration of I^{131} by salivary glands and stomach slices was reduced by the addition of thiouracil (0.02 mg/ml), KSCN (0.1 mg./ml.) or NaCN (0.1 mg./ml.), but it was not affected by the addition of TSH (100 μg/ml.) to the medium. None of these additives influenced the small I^{131} uptake found in liver and placenta. I^{131} uptake by salivary glands and stomach of the mouse, dog, and cow was similar to that in rat, except that there was less difference between the parotid and submaxillary glands.

Dormancy and Germination of the Docks (Rumex spp.)

STEINBAUER, G. P. AND BUFORD GRIGSBY

Assoc. of Official Seed Analysts. Fiftieth Annual Meeting: 112-117. 1960. (Journal Article 2641 from the Michigan Agricultural Experiment Station)

Seeds of eight species of dock were studied for germination requirements as to light, temperature, and substrate. The species studied were: Rumex acetosa, R. acetosella, R. crispus, R. obtusifolius, R. altissimus, R. mexicanus, R. orbiculatus, and R. verticillatus. The time required for attainment of maximum "ripeness for germination" varied with species. Maximum total germination and speed

of germination were obtained for all species by using light and alternating temperatures, 20-30 C. Only Rumex acetosella seeds were benefitted by use of KNO_3 solution. Most lots of seeds of Rumex acetosa germinated equally well in light and darkness. Minimum requirements for germination varied with species and age of seed. The needs of most seeds of Rumex for light is a coat effect.

Relation of Potato Tuber Growth and Skin Maturity to Infection by Common Scab, Streptomyces scabies

HOOKER, W. J. AND O. T. PAGE

Amer. Potato Jour. 37(12): 414-423. 1960. (Journal Article 2643 from the Michigan Agricultural Experiment Station)

Potato tubers were grown in a modified pot culture so that tubers could be observed at intervals throughout the period. Scab inoculum was sprayed on such tubers, and growth patterns as well as scab infection patterns were determined. Growth of tubers was the greatest at the apex. Tubers were inked and inoculated with spores of *Streptomyces scabies* after expansion had been initiated Scab lesions developed on the newly formed uninked surfaces at the margin of the inked areas. Infection of small Cobbler tubers developed at the apical end and was first evident approximately 7 days after inoculation as a ring of punctate necrotic spots around the apex. As the tuber expanded and as the necrotic areas enlarged, the separate points of infection coalesced to form a ring of necrotic tissue. Infection of tuber surfaces normally developed in areas of tuber skin which were expanding rapidly.

Cut surfaces of tuber tissue of either resistant or susceptible varieties permitted abundant visible growth of *S. scabies* after such tissue was either autoclaved or fumigated with propylene oxide. On freshly cut, washed tuber surfaces, *S. scabies* mycelium was sparse. Intact skin surfaces of mature tubers, which had been washed only, or auto-claved, or fumigated, prevented development of visible scab mycelium on the surface. Where such skin tissue had been broken, abundant mycleim developed under the broken skin on tissue which had been killed by autoclaving or by fumigating.

Relative Cleanability of Various Finishes of Stainless Steel in a Farm Bulk Tank

KAUFMANN, G. W.; T. I. HEDRICK; I. J. PFLUG; C. G. PHEIL AND R. A. KEPPLER

Jour. of Milk and Food Tech. 23(12): 377-381. 1960. (Journal Article Number 2647 from the Michigan Agricultural Experiment Station)

No significant difference was found in the relative cleanability of Nos. 2B, 3, 4, and 7 stainless steel finishes as measured by bacteriological tests. Therefore, it can be concluded that from a bacteriological cleanability standpoint, based on the conditions of this test, the selection of a stainless steel finish for a farm bulk tank or any comparable piece of equipment should be based on factors other than bacteriological cleanability.

Effects of Hydrocortisone, Prolactin and Oxytocin on Lactational Performance of Rats

TALWALKER, P. K.; J. MEITES AND C. S. NICOLL

Amer. Jour. of Physiology. 199(6): 1070-1072. 1960. (Journal Article 2656 from the Michigan Agricultural Experiment Station)

The effects on lactational performance of 0.25-, 0.5- or 1.0-mg. doses of hydrocortisone acetate, 1.0 mg. prolactin (1.0 mg=20 IU) or 1.0 IU oxytocin given twice daily, were studied in 90 mature female albino rats of the Carworth strain. Litter weight gains were used as a measure of milk secretion. When hydrocortisone acetate, oxytocin, or prolactin were injected individually, only hydrocortisone acetate at the 0.5-mg. dose level increased milk secretion significantly ($P<.05$) and neither prolactin nor oxytocin altered milk yield. When all three hormones were injected in combination, the effects on lactation were the same as with the individual hormones and only the combination containing 0.5 mg. hydrocortisone acetate increased milk secretion. These results indicate that adrenal glucocorticoids have the ability to increase milk secretion in the rat and it is believed that this effect is due to its direct action on the mammary gland.

Year-around Azaleas

LINDSTROM, RICHARD S.

Mich. Florist. 361: 15-18. 1961. (Journal Article 2771 from the Michigan Agricultural Experiment Station)

Greenhouse azaleas were flowered during the summers of 1959 and 1960 in order to determine the feasibility of producing year around azaleas. The growing practices were divided into three periods: 1) growing on period (from cut back to precooling), 2) the precooling period, and 3) forcing period (from the end of the precooling period until flowering). Varieties that were considered outstanding when grown at 60° F. were Alaska, Coral Bells, Dorothy Gish, Eclaireur, Memoria Sanders, Pericat Deep Pink, Red Wing, and Weinachten.

The Quarterly Bulletin

The Quarterly Bulletin of the Michigan Agricultural Experiment Station is issued in February, May, August and November. It presents progress reports on long-term major research projects and final reports on short-term projects.